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AMERICAN WATER WORKS ASSOCIATION

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THE HUMAN ELEMENT IN MEETING EMERGENCIES

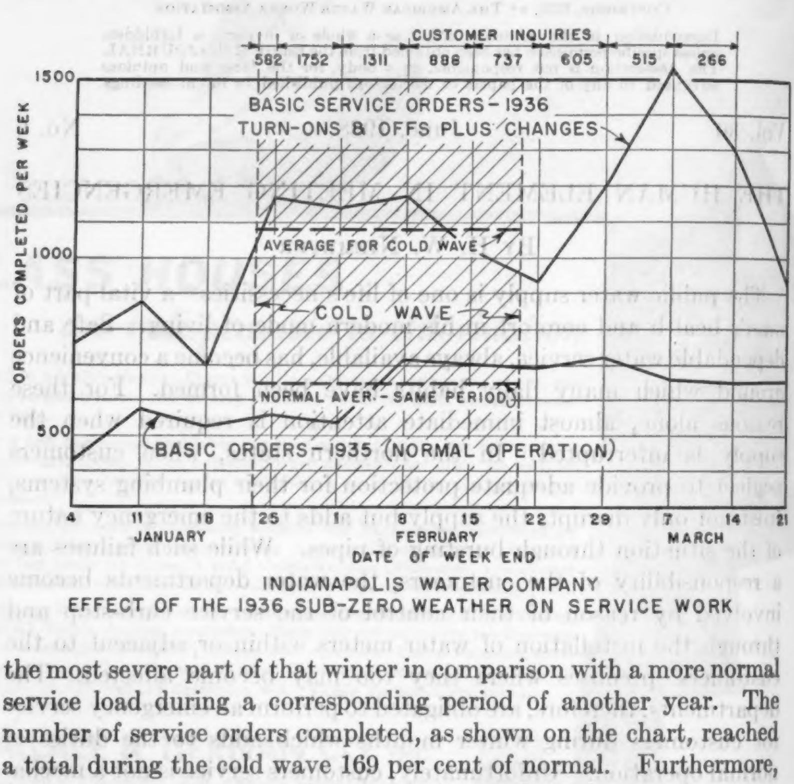
By H. W. Niemeyer

The public water supply is one of life's necessities—a vital part of man's health and comfort in his modern mode of living. Safe and dependable water service, always available, has become a convenience around which many daily habits have been formed. For these reasons alone, almost immediate attention is required when the supply is interrupted. In the northern states, when customers neglect to provide adequate protection for their plumbing systems, frost not only disrupts the supply but adds to the emergency nature of the situation through bursting of pipes. While such failures are a responsibility of the customers, the water departments become involved by reason of their control of the service curb-stop and through the installation of water meters within or adjacent to the customers' premises where they too may become affected. The departments, therefore, are obligated to perform an emergency service for customers during winter months which adds to the duties of normal operation. Unfortunately, customers service is not a mechanized operation which can be geared to meet the demand. It is one that depends almost entirely on the human element for an efficiency

Presented by H. W. Niemeyer, Assistant Superintendent of Distribution, Indianapolis Water Company, before the 31st Annual Meeting of the Indiana Section, American Water Works Association, Purdue University, Lafayette, Indiana, April 8, 1938.

which is essential to the best interests of the utility and to a satisfactory public relationship. Therefore, as the added burden and difficulty of operation increases with the severity of a winter, the human element in meeting emergencies becomes more and more significant.

In order to furnish a background for this discussion of the subject, the effect of the severe 1935–36 winter on customers service will be illustrated from records of the Indianapolis Water Company. The accompanying chart shows the burden placed on the company during



INDIANAPOLIS WATER COMPANY
EFFECT OF THE 1936 SUB-ZERO WEATHER ON SERVICE WORK

the most severe part of that winter in comparison with a more normal service load during a corresponding period of another year. The number of service orders completed, as shown on the chart, reached a total during the cold wave 169 per cent of normal. Furthermore, during the emergency period, snow, ice, and the low temperatures combined to create operating handicaps that doubled the normal time requirement to complete a service job. Snow and ice covered the stop boxes, made footing treacherous, and made streets extremely hazardous for driving. Stop boxes were found clogged to the top with ice. Basements and meter pits were often flooded from burst

plumbing and meters so that the stop box had to be used whatever its condition and return trips were required before service could be resumed. Continuous exposure to the low temperatures and biting winds caused extreme discomfort to the service men. These were the emergency conditions to be met. Certainly no semblance of efficiency or a satisfactory service could be expected from the service men unless their hardships had been recognized and minimized through forethought and precautionary measures. Perhaps these extreme conditions will never be repeated—we hope not—but it should be borne in mind that preparedness for the worst will lighten the men's burden and improve their service, not only for lesser emergencies, but for normal operation as well.

In order that the service men will be subjected to a minimum of hardship, the most efficient customers service possible must be built up through perfect coordination of all the personnel responsible for the service. Based on ideal employer-employe relations, the organization must be working in unison for a common purpose. Every detail of operation touching on the service—publicity, plumbing regulations, company policies, personnel, equipment, tools, record systems, and order dispatching—must be analyzed and supervised for all possible improvement. All unnecessary trips must be eliminated for the service men, the time required per job reduced, and the men must be given every regard for their comfort and safety. The efficiency necessary to the service men's well-being is also a component of satisfactory customers' service and must be considered for other desired results as well. Promptness of service is, of course, foremost. The contacts with the customers must be pleasant. Billings must continue without errors although the meter turnover is high. Water waste from burst plumbing and meters must be held to a minimum. The cost of the service must be consistent with the economical operation of the plant. The various phases of operation that lend themselves to achievement of these desired results will be briefly discussed along with suggested practices.

There can be no Utopia for the service man, because property deterioration and human carelessness and neglect are ever present. However, any step taken to induce a customer to overcome his neglect is a step moving toward the ideal and is the best service to customers that can, at the time, be given. Periodical warnings concerning the costliness of freeze-ups given the customers through the media of leaflets, posters in the office lobby, or by newspaper ads are

all good. These warnings should urge the customer to close all basement openings, to insulate all exposed piping and the meter, to keep the stop and waste valve in operating condition, and to have the service disconnected with the plumbing drained in case of an extended absence from a property. Verbal notices should be given to the customers by the service men and the meter readers in their routine work when a bad condition is noted. If but 10 per cent of the total freeze-ups could be avoided through work of this nature, it would prove worthwhile.

While most companies have adopted a penalty policy for meter damage by making the customer liable for repair costs, this plan is not very effective since it does not eliminate the cause and usually invokes animosity towards the company. Perhaps forceful correction of a faulty setting through service disconnection after a warning and a subsequent damage offense would be better. This plan would at least require a customer to guard his own service and would avoid repeat cases of damages and service calls. A company policy with respect to meter damage requires careful consideration so that customer relationship is not strained and yet is most effective in its influence.

As openings at the meter pit top permit escape of the warm air inside and reduce the temperature of a pit interior to below freezing, meter pit lids must always be locked in place, and the readers should be careful to see that they do not become lax in replacing them after reading the meter. This is a company responsibility that should not be disregarded.

Rigidly enforced company regulation of new or altered plumbing installations should be provided to insure frost protection to the service line and the meter. Basement settings for the meter should be used only where there is reasonable assurance that the meter is safe from frost. Stop and waste valves should be required and so placed that all runs of plumbing can be controlled by the customers and so that only a minimum amount of exposed piping occurs on the supply side of the valve. During an emergency it is a decided advantage to have this valve located on the supply side of the meter because, since in the majority of freeze-ups the meter is damaged, the customer can then stop resultant water waste pending the arrival of the service man. This valve also permits the service man to change the meter and to restore service quickly. Otherwise the curb stop would have

to be used, with a considerable delay if the stop box was covered or clogged.

The Indianapolis Water Company maintains a permanent service line record that is invaluable in times of emergency. Complete installation data are kept for each service, including the box location as measured from property lines or hydrants, a building diagram indicating the approximate meter location, the meter size and its type connection, kind of stop and waste valve, etc. The record is maintained in the service department so that all pertinent data are available either to the day or night service men. The record also allows plumbers to receive stop box location data by telephone and often permits the telephone personnel to give helpful advice to the customers as to how he can best aid himself. Curb markings with a distinctive color of paint (blue) are also used to give a line on the location of the stop box. The markings are made by the service men as they use the boxes in their routine work. While present regulations require the stop box to be located within building lines, there have been many boxes irregularly placed in the past and these curb markings have quite often been of particular assistance in quickly locating a box under dirt, snow or ice.

Economy is not to be measured by the investment in tools and equipment alone. The cost of service tools is so little that it is quickly offset by improved service and savings in time. In addition to the stop key, pipe wrenches and miscellaneous small tools, the service man's tool kit should provide adequate box cleaning tools and a dependable box locating instrument. Means for thawing ice in the curb boxes should also be provided (common calcium carbide has been recommended for this purpose). It is well to remember that adequate tools are essential to efficiency and that many second trips to complete an order can be avoided if the service man is equipped with tools to handle the unusual as well as the usual conditions.

It is important that automotive equipment be maintained in excellent mechanical condition because road failure of a car during an emergency means time lost for a service man when it can least be spared. Road failures can be held to a minimum through periodical inspections of a car and preventive maintenance by competent garage mechanics. Closed type cars should be provided with heaters and radiator covers, which will at least give the service man relief from

the cold between stops, and will provide a warm place for the men to remove their gloves to fill in their job reports. Windshield defrosters used in conjunction with the heater will provide the clear vision so essential to safe driving in the winter. Adjustable spot lights installed on service cars used for night emergency service are useful in many ways. They may be used to locate house numbers and to spot curb boxes or meter pits. A little light on the subject is particularly useful at night if a curb box has to be cleaned or uncovered before it can be used.

Work order forms should be so designed as to give the service man all necessary information and require only a minimum amount of writing on his part to report his work. The use of a check-marking system where identical data are repeated on a large number of orders is advisable. This item may appear unimportant at first glance but if you will add up the total writing involved in all of a day's orders, even though it be minimized, you will realize that the time element merits careful thought.

The telephone contacts with the customer form a phase of customers' service that cannot be overemphasized. These first contacts with customers in trouble have much bearing on their reactions, and control to a large extent the number of unnecessary trips to be made by the service men. The personnel selected for this work has a difficult assignment, for the contacts are made with all classes of people of different temperaments, many of whom can not speak distinct English, many who know but little about plumbing systems, and others who expect instant attention however trivial their trouble. In addition to primary requisites for telephone work, the personnel must be qualified and trained for service calls so as to be able to determine correctly the necessity for company service and also to determine the urgency of service requirements. Extreme care must be taken to obtain exact addresses and to record them correctly on the orders to the service department.

All orders must of course be centralized in the service department. Here they should be first checked for duplications and then for urgency of dispatching. Service orders should be routed to avoid overlapping of the service men's routes and to avoid any unusual delay on any one order. For instance, the city of Indianapolis is divided into eight one-man service districts. Orders are routed so that the men leave their headquarters, which are centrally located, each morning and noon and work out to the outlying edge of town by

mid-morning or mid-afternoon, at which time they receive by phone all urgent orders that have accumulated since they started out. These new orders are cared for as the men work back into headquarters. Approximately 60,000 service orders are handled annually by this group, with some 40,000 of these being originated by the customers. With the above system of routing, the regular service man can be on the job within 15 minutes to 3 hours from the time the customer notifies the office with the average time interval being not more than 2 hours. Rush orders demanding immediate attention are cared for by special trip of the repair men in the meter shop who have had service experience. The industrial meter service man and his helper also "float" in all districts to care for service to large installations and for any other unusual jobs that may be turned in by the district men. 24 hour emergency service is also available to customers through regularly assigned service men on duty during night hours, week-ends and holidays, the regular personnel being supplemented by others during emergency periods. A record of all incoming requests for service must be kept to avoid duplications and so maintained that the progress on any one can be given on instant call.

The service personnel itself is most important to satisfactory customers service. It is this group that must carry the brunt of an emergency and toil unceasingly without regard for themselves although the hardships are many and trying. Certainly they must be well qualified for their position—courteous, neat, accurate, fast, dependable, and physically capable of standing up under the emergency working conditions. They must be adequately trained, thoroughly schooled on the "do's" and "don'ts" of customers service, and above all imbued with a sense of responsibility to the customers. It thus follows that untrained men can not be employed temporarily for the duration of an emergency without courting costly mistakes. Since the size of the service group must necessarily, for economical reasons, be based on normal peak demands, the reserve service men must be drawn from regular employes, such as tappers, truck drivers, maintenance men or others who are already familiar with the work and who can be placed on the job with but few instructions and yet be depended upon for the work.

Reviewing the factors that affect customers service, it can be seen that the human element in meeting emergencies includes within the full scope of its meaning the management which establishes company

policies, the foremen who direct the work, the office personnel who handle the telephone calls and records, as well as the service man himself. It is only fair to the service man, if he is to accept his responsibility and give his best in service, that those who have acted before him must have first given their best. Those of us who watched the service men meet the 1935–36 emergency know that they are deserving of that consideration, and when that consideration is given, customers service will be at its best both in normal and emergency operation.

EDITOR'S NOTE: Facing this page is a reproduction of an inspection code sheet (5″ x 11″) used by the City Water Company of Chattanooga. The circumstances leading to its development and use were described in the paper "Public Safety as Related to Water Works Operation" by T. W. Coleman, published in this JOURNAL for July, 1937 (pages 1049–1058). The value of such inspection records is again demonstrated in the papers by members of the staff of the Indianapolis Water Company printed in this issue of the JOURNAL.

CODE FOR USE OF METER READERS
CITY WATER COMPANY
CHATTANOOGA, TENN.

METER READERS:

Please remember that you are the personal representative of this Company; that our patrons will judge the Company by you and by your conduct.

Help us avoid accident — Replace covers carefully.

If meter location is not shown on the meter reading sheet enter the location thereon.

Make an effort to read all meters for which you have meter reading sheets.

When reading meters use the code numbers below in describing the condition of meter, meter boxes and curb boxes.

Write the code number clearly on the meter reading sheet on the same line with the reading date in the column headed "Code."

OFFICE CLERKS:

Prepare orders to correct the conditions indicated by code numbers written on the meter reading sheet. As orders are issued, neatly circle the code numbers.

METERS

No. 1. Dirty Dial.
No. 2. Bad order dial.
No. 3. Meter covered.
No. 4. House vacant.
No. 5. Meter box broken.
No. 6. Round box lid broken.
No. 7. Square box lid broken.
No. 8. Round box lid small.
No. 9. Meter leaking.
No. 10. Service leaking.
No. 11. Meter box needs lowering.
No. 12. Meter box needs raising.
No. 13. Meter box needs cleaning out.
No. 14. Curb box lid.
No. 15. Curb box needs lowering.
No. 16. Meter in backwards.
No. 17. Fill in around meter box.
No. 18. Glass broken.
No. 19. Seal broken.
No. 20. Straight connection in box.
No. 21. Pointers out of line.

WATER COMPANY FIELD REPRESENTATIVES

By George O. Darnell et al.

All members of the Meter Reading Division of Indianapolis Water Company cooperated in the preparation of this paper on the subject "Water Company Field Representatives." Each submitted papers setting out what he felt a water company field representative should be and do to insure the efficient operation of the department.

There was then selected a committee of five of the group to study these papers and mold them into the paper which is now presented.

We believe that the term "meter reader" has become obsolete and should be relegated to the grave yard that holds the one cylinder automobiles and hoop skirts and in its place we should have the twelve cylinder title—"Field Representative."

According to Webster's dictionary, a representative is one authorized to act as agent for another or others. Then a Water Utility Field Representative must be that company's agent out in the field or territory where he works.

In practically all water utilities he is known as a meter reader, and in many of them that is just what he is, or in other words a statement taker.

Back in the days of horse drawn street cars, the name "meter reader" might have been appropriate, when the major requirement of a meter reader was the ability to transfer a correct reading from the meter dial to the meter reading sheet. There is however a vast difference between a field representative and a meter reader.

Since the job of meter reading has taken so much more important position in the water works field, it is essential that we raise the requirements of applicants for this position. They should be men in their early twenties, with at least a high school education, be able to write plainly and legibly, and be neat and accurate in figures.

A group document presented by the Meter Reading Division of Indianapolis Water Company at the 31st Annual Meeting, Indiana Section, American Water Works Association, Purdue University, April 7, 1938. Read by Field Representative George O. Darnell.

They should be neat in appearance, pleasing in manner, tactful, alert, and able to talk to the public in a convincing manner. They should also be able to pass a rigid physical examination.

After a man has been selected, then the important job of proper training must begin. He should be given a week or ten days schooling in the meter research laboratory. There he will learn the construction and operation of different types of meters and how to read them accurately and quickly. Then he should be sent with a field representative who has had several years experience reading meters, who is patient, and who will do all in his power to impart knowledge to the new man. At the end of this apprenticeship, if a man is studious, alert, and teachable, he should be able to do the work in a creditable manner. But in most cases it requires four to six months drilling to mold him into a real field representative.

In our Company the training of a field representative does not stop here. Meetings are held at least once a month in which every phase of our work is discussed and plans considered that will not only enable us to do better work but improve our working conditions as well.

Since $81\frac{1}{2}$ per cent of our revenue is derived from the sales of water by meter measurement, efficiency in the operation of the meter department is of vital importance to the Company. If every field representative does his work as it should be done then and only then the Company will receive the revenue to which it is entitled.

Once a year the meter men, together with one or more company officials, visit the various properties of the Company. At the filter plant a field representative gives a paper explaining in detail the operations necessary in the purification of the water supply. At one of the pumping stations another field representative gives a paper setting out the uses and purposes of every piece of pumping equipment. By the end of the trip papers have been given by these men describing practically every phase of the operation of a water company. In the preparation of these papers the men are obliged to make a study of the part of the system about which they are to write. In this way they become familiar with the Company's properties and are able to talk intelligently about any part of them.

We have just completed a series of five meetings in which was discussed every phase of construction and operation of meters. These classes in instruction were attended by an average of sixty-five members of the Commercial Department, including the meter readers,

billers, bookkeepers, contract window men and others. Previous to the start of these studies, the Commercial Department employes were asked to submit as many questions as they desired about meters and meter operations. A total of 246 questions were sent in and were answered by H. W. Niemeyer, who is in charge of our meter research laboratory and repair department. The operation of every type of meter from an ordinary $\frac{5}{8}$-inch to a detector and compound was explained thoroughly. Meters were dismantled and every part was called by its proper name. As a result of this schooling we should be better able to answer the many customer questions which we are asked during the course of a day's work.

We have discussed what a field representative should be. Now the question is, what should he do?

1. Procure correct readings of the meters.
2. Familiarize himself with the needs and demands of the customers on his route so that he will know when a meter begins to slow down.
3. Make inspections where consumption is unusually high.
4. Inspect occupied houses where route book shows water off. Also new properties under construction.
5. Inspect service lines for service leaks at least three times a year.
6. Solicit occupants of homes without city water to induce them to put in city water connections.
7. Contact the occupants of places where water service has been discontinued because of financial conditions, non-payment of bills or other reasons, and try to induce them to have service resumed.
8. Distribute literature to customers.
9. Build good public relations.
10. Make an annual survey covering all residences, stores, factories etc. as to occupancy, condition and water supply.

No doubt the first two duties, "procuring correct readings" and "detecting slow meters" are the most important for the field representative.

1. *Procure correct readings of the meter.*

All water utilities naturally expect their meter men to use all possible care in the reading of meters. Therefore, the utility should

see that the meters are set in good locations, instead of behind furnaces, in coal bins, and other places where it is difficult to get a correct reading of the meter.

Here are a few "don'ts", which if practiced by readers, will tend to eliminate mistakes in meter reading:

Do not try to read a meter while a customer is talking to you.

Do not read a meter when the clock is so dirty that the figures can hardly be seen.

Do not try to read a meter in a hurry. If you must hurry do it going from one house to the other.

Do not leave the vicinity of the meter until you have read the meter, made your subtractions and made sure the reading is correct.

If you follow these rules you will have very few if any mistakes in reading.

If an error is made by a reader and is not caught by the biller, the customer gets a high bill, and trouble commences. Be the overcharge large or small, the effect is the same. The customer comes into the office, usually in none too pleasant humor and demands a recheck of his meter. This is done at considerable expense to the Company and a corrected bill sent to the customer with a letter of apology. But no amount of explaining will convince some customers that the mistake was not a deliberate one and they will always remember it.

2. *Detect slow meters.*

No doubt most water utilities consider the procuring of correct meter readings the most important work of their readers. But is it? Would it be possible for readers to read month after month without making an error and still be little more than fifty per cent efficient? The answer is—Yes.

If the representative does not become familiar with the needs and demands of the customers, know when certain industrial and commercial consumers use wells, become a fair judge of how much water it takes to maintain certain living standards, he will be of little value to the company he represents. Meters are purely mechanical and cannot think for themselves. They may develop a loose gear; bits of grit may collect in the measuring chamber; or they may be subjected to a small dose of hot water. Then they will begin to

slow down. The alert representative will detect this slowing down and order the meters out for test instead of waiting until they stop altogether. Thereby he increases the utility revenues.

The men who read the meters must be wide awake at all times and watch for connections in front of the meters and test the meter seals to make sure no one has tampered with them. Since the advent of air conditioning a great many commercial and industrial consumers have drilled wells in order to have colder water and this is used in the hot weather instead of the city supply. Industrial plants use a great deal of water for cooling condensers and when these are not in operation the demand is smaller. Efficient meter representatives should be familiar with these conditions and when a meter shows a decline in normal consumption they should immediately make an investigation to determine the cause.

On the other hand, if the consumption drops considerably and the meter is ordered out as "broken" without an investigation being made as to the cause, an "averaged" bill may be sent to the consumer, which is incorrect, and cause a complaint. A special investigator is then sent who may find that a decline in business has caused the drop in consumption of water and that the meter is not "broken."

3. *Make inspections where consumption is unusually high.*

This service, which is more beneficial to the customer than to the Company, is almost a universal one among water utilities. No doubt this is one of the greatest builders of good public relations.

When a field representative reads the meter and finds an abnormal increase in consumption, notifies the consumer of the increase, and voluntarily makes an investigation to determine the cause, he has proven to the consumer that the utility really has his interests at heart and that it would rather have his good will than the few cents gained on account of leaky fixtures.

4. *Inspect occupied houses where route book shows water off, also new properties under construction.*

Perhaps some utilities do not have these troubles, but we do. For example, a customer may have had his service discontinued because he was leaving the city. When he returns it is late in the evening and the utility office is closed. He wants water service, and he remembers he has a friend who is a plumber. He persuades this plumber to turn the water on, promising to go to the water company office the first thing the next morning and have the service

contract resumed. The plumber, trusting to his friend's honesty, goes on his way, but the customer for some reason or other has forgotten where the water company's office is located, and if the field representative fails to stop at the reoccupied property the occupant may get free water indefinitely.

Another example exists where a contractor starts to build a new property and procures a plumber to install a water service to the basement. A connection is put on and the contractor proceeds to use the water for building purposes with no thought of paying for the service. Again the field representative must be on the job or the house will be completed and occupied without a meter being installed. During the years 1933 to 1937 inclusive, the field representatives of Indianapolis Water Company found 561 places where the water had been turned on without notice and without contract or payment. With few exceptions, we were unable to find out who was responsible for this work.

5. *Inspecting for service leaks.*

Is this a worth-while service? Undoubtedly it is. We consider it very important. We inspect service lines three times yearly. This is done by shutting the water off at the stop and waste if possible and listening on the line with the aid of the flash-light. Damp spots in the path of the service line, or reports of low pressure, are good indications of service leaks.

If the field representative is sure he has found a service leak, he can insure its prompt repair by pointing out to the customer that softening and wasting away of the soil may possibly result in damage to the foundation of the house or the cement walks.

During the year 1937 we detected 604 service leaks. Through these leaks it was estimated the average wastage amounted to 3 gallons per minute, or at the rate of 2,609,280 gallons per day. The largest leak found was wasting 75,000 gallons per day. Who could say this is not an important work?

6 & 7. *Soliciting occupants of homes without city water, and homes where city supply has been discontinued because of financial conditions, non-payment of bills, or other reasons.*

Practically all cities have their non-modern properties with their only water supply a well in the back yard, also modern or semi-modern properties where the city supply has been discontinued for some reason. Water utility representatives should constantly keep

in touch with these people, trying to persuade the owners of these properties to modernize their homes, and to persuade the occupants of properties where city water is off to resume the service.

Field representatives should be both salesmen and educators, trying to convince the owners of non-modern homes that they want to help them properly safeguard their health by using safe water. They should also tell them what it means to live in a modern, up-to-date home.

In most cases where the city water supply has been discontinued it is found that financial conditions are to blame. Therefore it is the duty of water utility representatives to do all in their power to get the water service resumed. If the customer owes a bill, and will promise to pay a small amount each month together with the current bill, turn the water on, and you will find that in most cases you have not only made a friend but a real booster for your Company. Even though these payments may be very small we must remember that four quarters in the cash drawer mean a dollar that you might never have gotten in any other way. In 1936 the field representatives of Indianapolis Water Company were successful in persuading 394 families to modernize their homes, or resume service that had been discontinued. In 1937 the total was 114.

As a result of a city sanitary ordinance and our continued solicitation efforts, we have reached the place where we now supply water to 96 per cent of the properties in Indianapolis. This does not mean that 96 per cent of the properties are thoroughly modern. We therefore not only have the job of persuading the remaining 4 per cent to install city water connections, but to educate those now using city water through yard hydrant or kitchen sink to modernize their homes. Therefore it is up to our field representatives to continue their solicitation and educational efforts and not be satisfied until every property in the city is completely modernized.

8. *Distributing helpful literature.*

What constitutes helpful literature? We believe the distribution of blotters or leaflets that educate the customers in the care of their lawns, when and how much to sprinkle, the proper way to protect their water pipes and the meters during extremely cold weather, and the necessity of keeping their plumbing fixtures in good repair so as to curtail wastage, is a worth while service. In instructing customers in the care of their lawns, we may be able to sell them more water. This is to our advantage as well as to the customers. If they protect

their plumbing and the meter during freezing weather, they and the water company are both benefited.

When we acquaint customers with the importance of repairing leaks, however small, they are the ones benefited from a financial standpoint. Nevertheless this service creates good will between the company and its customers, the value of which cannot be measured in dollars and cents.

Regardless of the value of this literature, we should bear in mind the more important duties assigned to field representatives, and if we feel this added duty has a tendency to cause them to neglect more important duties, then we should curtail the distribution of literature or discontinue it altogether.

9. *Making annual property survey.*

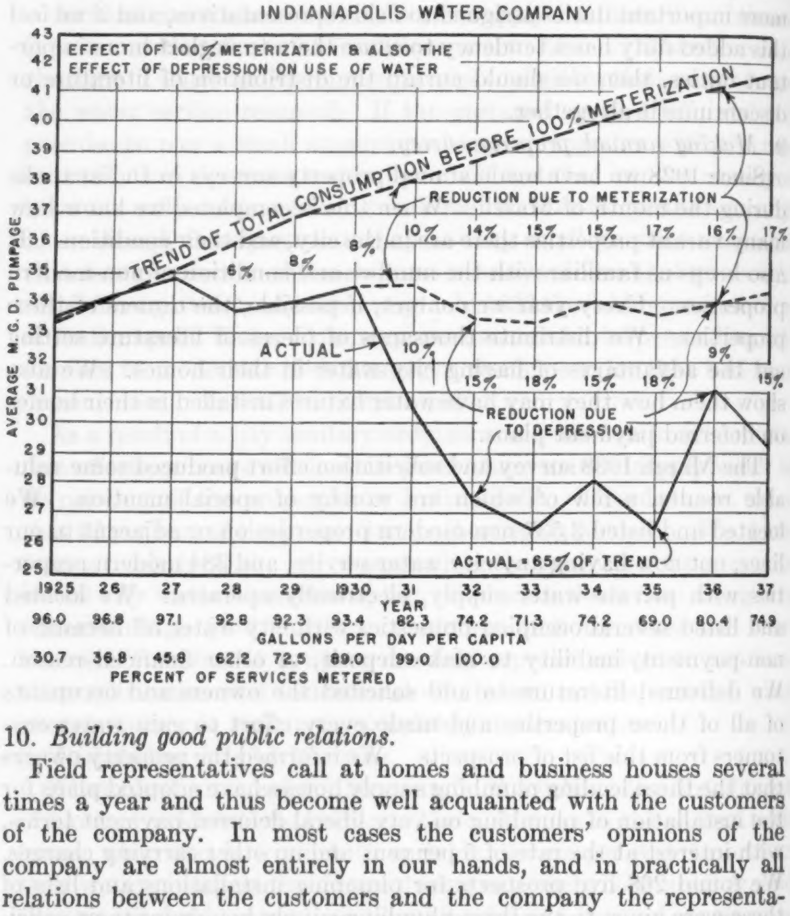
Since 1928 we have made annual property surveys in Indianapolis during the month of March. When this is completed we know how many vacant properties there are in the city, and their condition. It also keeps us familiar with the number and condition of non-modern properties. Every year we contact, if possible, the owners of these properties. We distribute thousands of pieces of literature setting out the advantages of having city water in their homes. We also show them how they may have water fixtures installed in their homes on deferred payment plans.

The March 1938 survey and solicitation effort produced some valuable results, a few of which are worthy of special mention. We located and listed 3,537 non-modern properties on or adjacent to our lines, not now having any city water service, and 384 modern properties with private water supply, electrically operated. We located and listed several occupied properties with city water off because of non-payment, inability to make deposit, or other financial reason. We delivered literature to and solicited the owners and occupants of all of these properties and made every effort to gain water customers from this list of prospects. We informed the property owners that the three leading plumbing supply houses have adopted plans for the installation of plumbing on very liberal deferred payment terms, with interest at the rate of 5 per cent and no other carrying charges. We found 268 live prospects for plumbing installations and lists of these were given to the three plumbing supply houses for their solicitation efforts.

By the end of March, water service had been resumed in 59 occupied properties where the service has been off, these patrons having

come to our office as the direct result of our friendly calls. The plumbing supply houses inform us that they have received many requests for estimates on plumbing installations as the direct result of our solicitation.

These solicitation efforts will be continued throughout the months of April, May and June and we have set as our goal a gain of not less than 300 accounts as the result of these calls.



10. *Building good public relations.*

Field representatives call at homes and business houses several times a year and thus become well acquainted with the customers of the company. In most cases the customers' opinions of the company are almost entirely in our hands, and in practically all relations between the customers and the company the representatives influence is apparent. We first hear most customer complaints, just or unjust, and our reception and discussion of these complaints usually impresses the customers with the fact that the water company is not a "soulless" corporation but that it has a real interest in the wellbeing of its patrons.

Most of the field representatives' contacts are with women, and women appreciate courtesy, impersonal friendliness, neatness, and consideration of their floors, rugs, washings, and other property with which they may come in contact.

Since no two people are alike, no hard and fast rules of conduct nor standardized greetings are possible. Field men must depend on their powers of observation and experience to make the best possible impressions on all customers. In many homes representatives are obviously necessary nuisances and should make their visits as unobtrusive as possible. The customers with real or fancied grievances are special cases with which they have to deal, but field men with tact can in most instances establish a tolerable relationship with these people.

Representatives should conduct themselves in such a way that few if any customer complaints against their conduct reach the office. The ability to answer promptly the many questions we may be asked, and interpret correctly the company's policy in the many situations that may arise, is most important.

Helping the customers to locate wastage in their fixtures is most desirable from the standpoint of public relations, but making them "minimum" conscious is quite another thing. The field-men in their zeal to please and help the customers must not lose sight of the fact that larger sales of water to the average users are most desirable to the water utility, and of great benefit to the buyers if properly used. They should also be able to speak intelligently and convincingly of the many healthful and enjoyable uses of water possible at so small an additional cost. Too many people sacrifice healthful water usage in order to stay within a minimum charge.

All water utilities should require their field representatives to look neat when they enter customers' homes. The best way to insure this is to uniform them. Uniform equipment should consist of a rather heavy suit, preferably of whipcord, with cap of the same material, together with a corduroy lined leather coat for winter wear. For summer wear lighter weight trousers should be provided, as well as shirts with the utility insignia on the left pockets. For rainy weather a serviceable rain coat or cape should be provided for the purpose of protection to the men as well as keeping the route books dry.

We have set out what we believe a water company field representative should be and do. But two questions arise: 1. Are we

being asked to do too much? 2. Are we doing work that rightfully belongs to some other department? Our answer to both questions is—No.

Field representatives are the only employes of a water utility who come in contact with all of its customers at frequent intervals. The customers know them and do not hesitate to admit them to their homes. If they are reading too many meters to take proper care of these extra duties, which are very important, then the number of meter readings required daily should be reduced.

If this work is assigned to some other department, the expense of taking care of it will materially increase. Why subject customers to an unnecessary bother when the field representatives can do this work in a more efficient manner? The less we annoy our customers the better their feeling will be toward the company.

The duties set out for a field representative are many, yet we think that every one of them is necessary in the efficient operation of a meter reading department.

INCREASES IN WATER DEMAND AND THEIR CAUSES

Especially With Relation To Water Use For Air Conditioning

By O. C. Holleran

At last year's convention of the American Water Works Association in Buffalo, there were presented the results of a Bureau of Foreign and Domestic Commerce survey of the effect of air conditioning upon city water supplies in 93 cities of more than 100,000 population. From the time of the publication of the findings in that study, there has been a growing demand that similar data be published on as many additional cities as possible.

As a result, the Bureau has made a new study to take in all of the 486 cities of more than 20,000 population in the United States. This new study shows conditions on December 31, 1936. This date was selected partly in order to relieve the first group of metropolitan cities of making additional schedules and partly because 1937 data were not available in a large percentage of the cities.

Out of 486 cities of more than 20,000 people 434 completed and returned schedules. Some of the 52 cities unreported receive their water supplies, and are inseparable, from one or another of the great inter-city and district systems. The East Bay Municipal District at Oakland, California, which supplies nine cities and a number of villages, is typical. The remainder simply failed to send in a schedule.

From the information gathered from these schedules, certain underlying facts of the present situation have become apparent. Of all of the facts developed by this study, the most startling one is the apparent lack of knowledge of actual conditions within their operating zones shown by the responsible water authorities of a great many communities. In a number of schedules the authorities have specified that in their opinion water use was due to air-conditioning installations only to state later that they had no record

A paper presented at the New Orleans convention, April, 1938, by O. C. Holleran, Chief, Industrial Marketing Unit, Marketing Research Division, Bureau of Foreign and Domestic Commerce, Washington, D. C.

whatsoever of the number of air-conditioning installations in their communities nor the amount of water being used by them.

As a matter of fact, close analysis of the replies indicates that reviving industry has had a great deal to do with the largely increased use of city water during 1935 and 1936. In the middlewest and southwest there have been some amazing increases in water use by individual cities; as for instance, in Dallas, Texas, where there was an increase of almost a billion and a half gallons in 1936 over 1935. In this case the Dallas authorities specifically state that the increase was due partly to the great international exposition and partly to drought conditions in the area during that year.

A great many of the Middle Western cities also reported very large increases in water use during 1934 and in practically every such case the water authorities commented upon the fact that drought was the major cause of these increases.

On the other hand, many cities pointed out that reviving industry in 1936 was the cause of increased demand upon their systems. Thus Fort Dodge reported that its 12 per cent increase in 1936 over 1935 was due to the opening of a new packing plant, while the 12 per cent increase at Grand Rapids was attributed to increased manufacturing activity.

Figures from a considerable number of cities which reported actual use of water for air conditioning purposes, indicate something of the possible developments of the situation. Thus Baltimore reports that during the season of peak demand, water for air conditioning purposes amounts to 10 per cent of delivery capacity; Brookline, Massachusetts reports a demand running from 11 to 22 per cent of capacity; Petersburg, Virginia, 11 per cent; and Waterbury, Connecticut, 10 per cent.

Incidentally, if the experiences of two cities may be considered as an adequate sample, it would seem that the most efficient way to reduce water waste is through a completely metered service. At least, Jackson, Mississippi, reported a decrease of 30 per cent in 1936 under 1935, and Jackson, Tennessee, a decrease of 38 per cent in the same period, attributable to complete metering.

I think you will agree, that this whole question of causes of increased use of city water is sufficiently serious to justify every water department in the country in setting up some plan whereby they may keep accurate records of the purposes for which water is consumed, lest they find themselves blaming one cause for water shortage when actually the source of trouble lies somewhere else.

It is easy to see that this might happen when it is considered that 34 cities reported that they have no record of any air-conditioning installations in their communities, yet in most of them there has been a reasonably constant increase in water demand during the past few years and in several of them this increased demand has at one time or another been attributed to the use of water by air-conditioning equipment. Such a situation might well prove embarrassing to the water authorities of a city, if, in case of a shortage, the facts were produced to show that an attempt had been made to correct a non-existent evil while there was no knowledge of an existent danger.

In order to keep such records of water use, it is, of course, necessary that the head of the water department arrange with other city administrative departments for instant exchange of information on every installation of any type of equipment or other development of any sort which means an increase in water consumption. The cost of such record keeping would be comparatively a minor one. Its value in furnishing definite indications of a trend and, thereby, allowing ample time for adjustment of services might well be invaluable.

In any such arrangement the measurements of sewerage and other waste-disposal facilities of the community, and the extent to which they were being used, should be included since in several cities today the lack of adequate sewerage disposal facilities is proving a handicap not only to the further sale of air-conditioning equipment using water in quantity but to the installation of any other type of water-using equipment for either industrial or commercial purposes. Indianapolis, for instance, reports that sewers serving its business district are working now at capacity and, therefore, any further increase in water waste in the business district must be limited as far as possible despite the availability of an ample water supply.

Another angle of the question of water uses arises from the problem of supplying large amounts of city water for temporary demands, whether for air conditioning use or for other purposes. It is quite obvious that, if a certain section of a community or every section of a community must supply twice as much water during certain seasons of the year as during the remainder of the year, it must have the facilities—pumping, treating and delivery—to meet the peak demand. But, if this peak demand is for, let us say, only 3 months of the year, it means that 50 per cent of the water works facilities are idle three-fourths of the time. They represent a non-earning investment which creates an extra financial burden of over-

head, depreciation and interest on investment, upon both the water department and upon the city itself.

There are, of course, some cities which, because of special conditions, expect to face a permanent condition of this sort because of a local situation which involves heavy population increases for part of the year. Urbana, Illinois, is typical of cities which must habitually be prepared for large increases in water use during part of the year because the university population during the term almost doubles the population of the city. There are also a number of summer resort cities, such as Atlantic City, which are similarly situated.

Many cities, whose supply depends upon ground water, have found it necessary during the past few years to add surface sources for additional raw water supplies. In the cases of some of these cities in the Middle West and Southwest, this need has been due to a lowering water table possibly caused by recurrent drought conditions. In other cases the additional sources have been installed simply because added water demand—caused by population growth, the creation of new industries, and the installation of air-conditioning equipment—has rendered the available ground water supply insufficient to allow an adequate margin of safety.

The new survey shows that many, possibly a majority, of the air-conditioning installations using the largest quantities of water depend upon private wells for their supply. This is a very satisfactory solution where the ground water is sufficient in quantity, but there is always the danger that the city will find itself called upon to supply water to some or all of these units because of a lowered water table created by the high draught from private wells. Atlantic City, which is one of the few larger cities which definitely attributes the greater part of its increasing water use to air-conditioning equipment, points out in its report that part of this increased demand is due to failure of private wells previously used by large air-conditioning installations. Gayton at Chicago has also had some experience in dealing with this problem in the suburban industrial districts of that city.

Another problem of some seriousness, to which attention was called last year, becomes more evident in the study of conditions existent in this large additional number of individual cities. That is the number of cities where the water supply system is unbalanced in one way or another. One city says that they are able to increase pumpage 350 per cent with present equipment, but their mains will handle only a 5 per cent increase, over the average now

being delivered. Another says that mains will carry an increase of 1500 per cent as they stand but the pumps will deliver only an increase of 300 per cent operating at capacity. A third is equipped to pump 10 times the present average, the mains will carry an increase of 500 per cent, but safe yield of present sources is only 250 per cent. Others report entirely adequate margins of safety on pumping and mains but with their treatment facilities being used at near capacity.

Furthermore, it appears that, due to the great burden of work imposed upon the responsible authorities or because of a division of responsibility for public water supply between different executive offices of a city, that in some cases the authorities themselves do not fully realize that the system is unbalanced. At least one city authority specifically mentioned the fact that, in gathering data to complete the schedule, he was surprised to find how little he could increase actual delivery because of a bottle-neck of this sort. And, incidentally, another city engineer found that his meters had not been working for a considerable time with the result that many hundred million gallons of water had been pumped into the service mains with no measurement at all.

Summarizing the situation as it apparently exists, due note should be taken that the danger of over-demand from air-conditioning equipment which appeared so very serious a year ago has been markedly reduced in seriousness during the past season. This is largely due to the fact that practically all of the air-conditioning equipment manufacturers have produced water-conserving equipment and are putting considerable stress on selling such equipment in preference to the water-using types. Furthermore, the development of the "room cooler" which uses no water at all, is tending to replace to some extent the very small residential and single office type of water-using equipment. While no actual figures are available, I believe that your experience will indicate that new installations in your communities are showing a greater and greater percentage of non-water-using equipment. This does not by any means indicate that there is not a problem involved in supplying water for air-conditioning equipment, but simply that the speed of growth in seriousness of the water supply problem is likely to be slower than we had previously thought.

Regardless of whether the increased demand comes from any one cause or from several, the fact is that during the past three years there has been a reasonably constant increase in water demand in practically every city. In 1936, 388 of the 434 reporting cities

showed increases over 1935 demand. These increases ranged from a fraction of 1 per cent to as much as 50 per cent in individual cities. It is true that many of the cities in this group are known to be among the best markets for air-conditioning equipment but it should also be noted that in many cases the water authorities have stated that they are unable to specify what part of the increase is due to any given cause since they keep no record of the purposes for which water is supplied. We are, therefore, unable to formulate any satisfactory estimate of what part of these increases are due to air conditioning and what part to other causes.

On the whole, we may assume that in a considerable number of systems there is a definite danger of any largely increased demand placing an undue burden upon the system and, therefore, there is a need that every care should be taken to know what increases may be expected, whether such increases are to be year round demand or seasonal demand, and whether or not such increases will force some form of control upon water users because of local limitations of supply or of plant and equipment. And, last if not least, it may be pointed out that in this field, it is seldom indeed that the experience of one city is of concrete value to another except in broad generalities. The extremely wide variation of climate, raw water supplies, city characteristics, type of equipment and purposes for which water is used make every city a separate and individual problem which must be analyzed and solved on its own merits.

The whole problem of public water supply may also be expected to grow steadily in importance. With every passing year, our annual increases in population, especially in the already densely peopled sections of the country, the concentration and growth of industry, and the modernization of both industrial and residential equipment, points to an equally constant increase in water demand. The free use of water and the unnecessary wastage of water must sooner or later be checked simply because of limitations on sources of supply. By keeping adequate records and accumulating a thorough knowledge of every question involved in use and disposal of the public water supply now, authorities will be able when the time comes to insure a safe and equitable control of the problem instead of being forced when an emergency arises, to depend upon recommendations hurriedly made and, therefore, liable to create conditions even more serious than those they are supposed to correct.

MEETING DEMANDS CREATED BY AIR-CONDITIONING

A Round Table Discussion

By D. L. Erickson, T. L. Amiss, L. S. Vance, and W. V. Weir

D. L. Erickson. The problem of meeting the water demand created by air-conditioning in Lincoln, Nebraska, probably has been much easier than in most cities, for the reason that, in 1932, Lincoln developed an additional source of supply from the Platte River Valley at Ashland, which furnished extra capacity just before air-conditioning became so popular. As this water has a maximum temperature of sixty degrees, the new supply proved to be ideal for this purpose, and a large amount of air-conditioning has since been installed.

At the present time, all of the theaters, practically all of the restaurants, about one-half of the office buildings, a large portion of the retail merchandise buildings, a part of the hotels as well as a considerable number of residences have installed air-conditioning equipment.

Lincoln's water rate schedule had a top of fifteen cents per thousand gallons and a bottom rate of ten cents per thousand gallons. City authorities felt that it was desirable to take advantage of this new water load, thereby increasing its water revenue, so the water ordinance was amended so as to permit the use of water for air-conditioning and sprinkling purposes at the ten-cent rate when measured through a separate meter. As a result thirty-eight of the larger air-conditioning systems have installed separate meters. During the year 1937, these thirty-eight installations used 59.26 million gallons of water during the cooling season and it is estimated that approximately an equal amount of water was used during this same

A round table discussion held during the New Orleans convention, April, 1938.

The participants were: D. L. Erickson, City Engineer, Lincoln, Nebraska; T. L. Amiss, Superintendent, Department of Water and Sewerage, Shreveport, Louisiana; L. S. Vance, Chief Engineer, Louisville Water Company, Louisville, Ky.; and W. V. Weir, Superintendent, St. Louis County Water Company, St. Louis County, Missouri.

period by the more than two hundred smaller air-conditioning installations that secured their water through a regular meter, making a total estimated water use for air-conditioning purposes of approximately one hundred twenty million gallons.

It is interesting to note that the owners of the thirty-eight installations having separate meters used approximately fifty million gallons of water for ordinary domestic consumption during this same period in addition to the water used for air-conditioning in the special meters. In other words, these thirty-eight owners increased their use of water about one hundred twenty per cent by installing air-conditioning equipment.

The largest air-conditioning installation serves our largest retail store and has a 250-ton refrigeration capacity. The installation was very carefully designed and is probably one of the most efficient installations in the city. The owner has kept careful detailed daily records of the operation, from which the following information has been developed.

Air-Conditioning Installation, 250-ton Refrigeration Capacity

(In operation daily except Sundays during operating season)

1937 WATER CONSUMPTION	TOTAL 120-DAY SEASON	AVERAGE FOR 120 DAYS	MAXIMUM DAY
Total gallons	10,895,250	90,600	150,000
Total gallons per ton	4,358	362	600
Gallons per minute		158	264
Gallons per minute per ton		0.63	1.05

It will be noted that this installation used a maximum of 600 gallons per day per ton of refrigeration or 1.05 gallons per minute per ton. This largest installation was only operated from 7:30 A.M. to 5:00 P.M., and a greater portion of the air-conditioning water in Lincoln is used during these hours.

An examination of the pumping station records indicates that the hourly station pumping rate, due to the use of water for air-conditioning purposes has increased from $11\frac{1}{2}$ to $15\frac{1}{2}$ million gallons per day, during the nine-hour period from 8:00 A.M. to 5:00 P.M. or a one-third increase in pumping rate during this period of day. The maximum hourly peak of 30 million gallons per day occurred from 7:00 to 8:00 P.M. and was largely caused by the water demand for lawn sprinkling purposes. At this hour it is estimated that only approxi-

mately 25 per cent of the maximum air-conditioning rate is in use so that in Lincoln a majority of the air-conditioning load is not coincident with the hourly peak.

When considering twenty-four hour peaks, however, the entire air-conditioning load may be on peak, because it is entirely possible that the maximum use of water for air-conditioning may be on the day that a maximum amount of water is used for sprinkling. In Lincoln, therefore, the air-conditioning load has created a small demand on the pumping facilities and on the city's distribution system, but a substantial demand on the daily quantity of water available. Fortunately, due to the new additional supply, Lincoln has so far had plenty of water for this new demand.

Some will probably question the policy of making a low water rate for air-conditioning purposes, but so far it has worked out satisfactorily to all concerned and it has brought in additional revenue to the Water Department that was greatly needed.

Future developments, of course, are problematical, but indications are that the demand for air-conditioning equipment is flattening out in Lincoln; and with the probable increased efficiency of future installations, it is believed that no serious problem will confront the water department in the future from this source.

THOMAS L. AMISS. From my observation it seems to me that the crisis of the air-conditioning as a menace to the water supply is passed. The results of a survey made by my department very definitely shows little use of water over and above our peak period during July and August. I will try to substantiate that fact later with information of actual usages.

On the first of the year we had 17,134 Accounts, all metered and classified as follows: 13,761 Domestic, 128 Industrial and 3,245 Commercial; 80.36 per cent, 00.74 per cent and 18.9 per cent respectively. The 3,245 Commercial Accounts consume 23.7 per cent of the metered pumpage, the 13,761 Domestic 33.7 per cent and the Industrial 42.6 per cent. All of our air-conditioning sales are classified as Commercial. There are none in the Domestic or Industrial classification.

In studying the use of water for these air-conditioners using evaporative condensers find an average use of 0.94 gallons per H.P. hour with a high of 1.74 and a low of 0.05 gallons. On 2 Accounts where a direct flow is employed find it takes 106.8 and 46.8 gallons per H. P. hour for a 7½ H. P. and 15 H. P. machine respectively. In the city hall a 3 H. P. machine wastes into the sewer 130.8 gallons of

water per H. P. hour to air-condition one room 20 x 30 feet. These were the first installations made some eighteen months ago. Since then all air-conditioners are equipped with evaporative condensers.

When the Electrolux ice machine was first introduced, I found it necessary to secure first hand information concerning the use of water because of complaints I had from users as to excessive water bills. A study disclosed this fact, that a 6 cubic foot machine used and wasted 2.04 gallons per hour. It was soon found out that the purchaser would not stand this expense and other means were employed, eliminating the use of water.

I see no reason for a Superintendent to worry about air-conditioning demands, first, if has a reserve supply equal to 60 per cent of the requirements as stipulated by the National Board of Fire Underwriters. Second if he has a 100 per cent metered system and is accounting for around 90 per cent of the water pumped. In a 100 per cent metered system he can put his finger on where the water is being used and correct his distribution system to accommodate a shortage.

In my opinion the dual water system as now being practiced using well supplies for air-conditioning is going to be a greater menace to the water superintendent than any demand for more water he could experience, and, if wasted into the sanitary sewer without charge, is unfair.

L. S. Vance. The increase in air-conditioning installations has not imposed any unusual strain on the city water facilities in the majority of cities. This statement was substantiated in the replies received to a questionnaire sent out in January 1938 to 45 cities with populations over 200,000 and from which 39 replies were received. Thirty-four cities answered "NO" to the question "have you to date or do you anticipate an embarrassing load from air-conditioning."

Of the 5 cities not definitely answering "NO" only 3 have already had, or expect to have, embarrassing loads due to their air-conditioning installations, a fourth merely stated that they were opposing air-conditioning installations which wasted water, and the fifth city had not as yet had such a load but expected to be embarrassed as to capacities unless this type of use was controlled.

It is interesting to note that three of these five cities which have already had or possibly expect to have trouble have far below the average water bills for all classes of consumers (New Orleans, Philadelphia and Washington). In other words, in these three

cities there is no self operative incentive for the curtailment of luxury use or waste of water.

Mr. E. R. Ronald, a consulting heating and ventilating engineer, in a paper presented before the Kentucky-Tennessee Section Meeting in March, compared installation and operating costs for different methods of cooling air-conditioning condensers of sizes to handle the refrigerating load of 100 tons capacity as follows, using the Louisville water rate, which is considerably below the average for this class of consumption, and assuming a 300 hour operating month and electric power at 3¢ per kilowatt hour.

(A) Cooling the condenser with city water, the original installation cost of supply and waste piping would be negligible, operating cost 3,600,000 gallons of water per month	$250.00
(B) Private well supply, installation	$1,400.00
Operating cost per month	85.00
(C) Evaporative condenser, installation	2,500.00
Operating cost per month	60.00
(D) Natural draft cooling tower, installation (50 ft. or less above condenser)	2,000.00
Operating cost per month	100.00

To put this comparison on a more easily understood basis; assuming a three month cooling season and interest and depreciation or retirement at 12 per cent per year the yearly cost would then be

City water cooling	$750.00 per year
Private well cooling	423.00 " "
Evaporative condenser cooling	480.00 " "
Natural draft cooling tower	540.00 " "

This would again indicate that "old man percentage" is still working on the side of and attempting to protect the public water supplies.

In general, special regulation of use of sewers or storm water drains in connection with air-conditioning except in special isolated instances, has not and probably will not be used. Combined sewers or storm water drains, to accommodate maximum intensity rainfalls are normally designed for run-off capacities far in excess of maximum demands which might be placed on them by air conditioning installations. It is true that the absorption of sewer or drain capacities for a purpose other than that for which they were designed should call for regulation but this is difficult to administer and in most cities

beyond the province of the water department. Of course, prohibition of the use of city sewers or drains for handling air-conditioning condenser effluents, will force the use of other means of cooling condensers and relieve the water department of this heavy demand.

A special water rate for special or luxury use of water is a type of regulatory measure which is likewise difficult to handle. This method of solving the possible problem is anticipated by only 4 of the 39 cities with two additional cities considering it as a possibility.

Regulations requiring the use of cooling towers or evaporative condensers are anticipated as the probable solution, if the necessity should arise, in 17 of the cities answering the questionnaire. This method of control of an unattractive type of maximum consumption demand appears to be the best and most economical and easily administered solution to this possible problem.

It is interesting to note that 10 of the cities replying to the questionnaire indicated that they would increase plant capacities to meet this type of load. Unless increase in plant capacities are needed for other reasons this hardly seems an economical solution. Without a higher than normal margin of profit, it is questionable whether a high load factor for only three months of the year can justify the relatively large investment required in purification and pumping plants and transmission and distribution systems. Careful investigations and conservative thought should be applied before expenditures for such purposes are authorized.

W. V. Weir. Today the infant industry "Air-Conditioning" is presenting one of the major problems in the field of water supply. A graph of summer air-conditioning or refrigeration installations made in the past few years shows a curve rising at an accelerating rate. Where this curve will level off is impossible to say. We only know that for some time to come more and more water will be required for air-conditioning and that this water will be needed during the season of peak water consumption. Because of these simple facts we properly recognize this additional water demand as a problem which will now, and in the future, require careful study.

Generally speaking, this newly created water demand will begin in May and will end in October each year. It will coincide with the present peak-load season. More water will be required on the hot days than on the cool days. The load will be an added increment to the present peak-load demand.

Most water plants and distribution systems as they are now built

will take care of existing loads. Since it will usually be impossible to refuse to take on this coming additional load, we are therefore confronted with the problem of reinforcing or making additions to our present water plants and distribution systems, or of reducing present peak loads so that the existing water systems will have capacity available to supply this additional water.

From a strictly engineering point of view the problem is not especially difficult unless this new load develops so rapidly that it is impossible to keep ahead of it. This discussion will touch only two phases of what may be done in the way of construction to meet this new water demand.

ELEVATED STORAGE

The accompanying figure 1 is typical of water consumption on a peak day. This graph shows the actual water demand of the consumers of the St. Louis County Water Company on July 14, 1936, and represents the consumption during the peak day of our peak season. The consumers are mainly residential, although fourteen country clubs and quite a number of truck gardeners are served. The population served was about 200,000 and the consumers were 99 per cent metered. To allow comparison with other systems the consumption is shown in gallons per capita per day.

The solid line represents the water taken out of the distribution system during the day. This curve is similar to other peak day curves which have been published in various water works literature. The broken line represents the water pumped into the distribution system. It will be noted that, in the late afternoon during the peak period, water was put into the distribution system at the rate of 197 gallons per capita per day while it was being taken out at the rate of 220 gallons per capita per day. The difference between these figures represents the rate of drawdown in our elevated storage which consists of five standtowers and two elevated tanks. Approximately ten per cent of the peak water demand was therefore supplied by the elevated storage, the cost of which, including the land occupied by the tanks, was less than three per cent of the cost of the plant and primary mains.

To have supplied the most difficult ten per cent of the peak demand by additions to the plant and mains would, however, have required more than a ten per cent additional investment cost. Any method which will accomplish these results with only a three per cent addi-

tional investment cost offers an economical method of taking care of additional water demand.

In the past our elevated storage has been allowed to "float on the line." This coming summer we are going to adopt a procedure

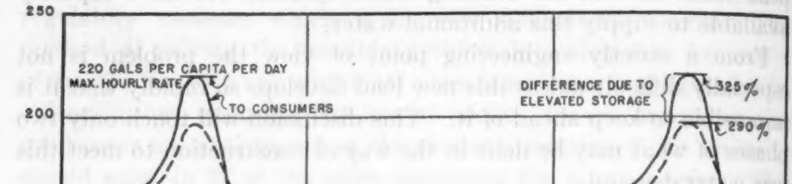


FIGURE 1. RATE OF CONSUMPTION—MAXIMUM DAY JULY 14, 1936
ST. LOUIS COUNTY WATER CO.

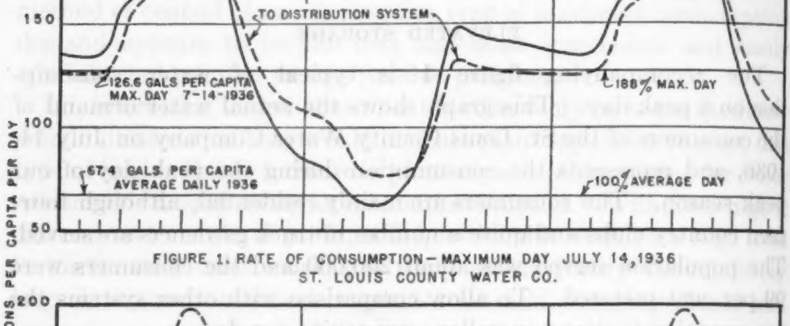


FIGURE 2. PUMPAGE FROM PLANT AND REPUMP RESERVOIR JULY 14, 1936
ST. LOUIS COUNTY WATER CO.

used by some other water systems of conserving the storage during the hottest days until the heavy afternoon draft begins. Graph No. 1 shows that we discharged a great deal of our supply of stored

water into the distribution system between 7 A.M. and 3 P.M. and did not obtain the maximum benefit of the elevated storage during the hours of peak consumption.

The elevated water storage in our system does not approximate an amount which can be considered as adequate. In our system, and in a great many other systems, a very economical method of handling the additional water demand created by air-conditioning is the installation of more elevated storage.

REPUMP STORAGE

A variation in the use of stored water is the practice of installing "repump storage" or reservoirs at ground level from which water is pumped to the distribution system during periods of above-average demand. This method is especially deserving of study where the pumping and purification plant is remote from the distribution system. It enables the plant and transmission mains to operate at a nearly uniform rate; or if off-peak power rates are available, it enables the plant to deliver a large quantity of water to the reservoir during this off-peak period, thus taking advantage of these lower power rates.

Figure 2 shows as a broken line, the pumpage into the distribution system of the St. Louis County Water Company for the peak day, July 14, 1936. The pumpage from the plant is shown as a solid line. It will be seen that the plant pumpage curve bears no resemblence to the actual water consumption curve. For eighteen hours of the day the plant pumped to the reservoir which is located eight miles away at an elevation 270 feet higher. For six hours, from 3 P.M. to 9 P.M., the plant pumped direct into the distribution system, assisting the booster pumps in handling the peak load. It will be noticed that at no time during the on-peak hours did the main pumps or the booster pumps operate at a rate greater than 117 per cent of the average for the day, while the total water delivery during the peak period was 155 per cent of the average for the day.

The use of these booster pumps and reservoir has made unnecessary the construction of additional pumping and purification plant facilities and additional transmission mains to take care of the peak hour demands. The addition of a re-pump storage supply to an existing water works system built for the maximum hourly load will enable the plant and mains to handle a total daily consumption approximating the present maximum hourly rate; or in other words,

allow the existing plant to handle maximum days 25 to 50 per cent greater than at present. Repump storage deserves consideration as a method of meeting the air conditioning water demand.

REDUCE PRESENT PEAK LOADS

The most economical method of meeting the growing water demand created by air-conditioning would be to do so with our present systems. If we can reduce the present peak demands, our systems, which are now built to handle these maximum demands, will have capacity available to supply water for air-conditioning installations.

A further inspection of the accompanying Graph No. 1 will show the abrupt peak and the enormous valley in the curve of the consumers' water demand. In St. Louis County we have constructed a distribution system to handle for a short time 325 per cent of the average daily demand. Even on the peak day we only handled 58 per cent of the water the system was built to deliver.

Considering this as a typical consumption curve, it should be realized that it is very uncomplimentary to the management of the water works industry. There is probably no other industry, with such a poor load factor, which has not tried to do something to improve it. The usual effort is toward filling up the valley in the production curve. Admitting that there are very few available markets for additional water in the winter or during the night, there is little excuse for not trying to lower the peak hour requirements.

Few of us offer to sell water on an off-peak basis, yet many of us buy power on that basis. A proper analysis of costs and rates will show that it would usually be advantageous to offer inducement rates to make it worth while for certain consumers to refrain from using water during the peak hours. In St. Louis County, Missouri, we have embarked on such a project in a small way. By making a reasonable reduction in water rates, we have already induced two large country clubs to confine the irrigation of greens and fairways to the hours between 9 P.M. and 7 A.M., and by so doing have kept a draft of 1000 gallons per minute off our peak-hour demands.

We have barely touched the field of off-peak rates. The commercial irrigation load will probably be the best load to try to control by this device. Truck gardeners, greenhouses and golf clubs should be willing to refrain from using water during the peak hours of the summer season if a commensurate reduction in water cost is available.

In contemplating the growing air-conditioning water demand there

is a tendency to consider it as an undesirable load since it comes during the peak season. However, the consumer who causes the wide variations in the load curve is the ordinary householder who feels that he has to sprinkle his lawn between 6 and 8 P.M. every evening. Air-conditioning load is not nearly as undesirable as the sprinkling demand placed on the water system by the householder.

In an effort to correct this habit of sprinkling every evening, we distribute free the U. S. Dept. of Agriculture bulletin on "Planting and Care of Lawns" and keep repeating in our advertisements that (quoting from this bulletin) "during hot dry weather the lawn should be watered infrequently but thoroughly. . . . The lawn may be watered at any time of the day or night." If the consumer follows this advice he waters his lawn once or twice a week instead of every day. He also takes water over a longer period of time to get the proper amount of water on his lawn. We expect this program to reduce the maximum demand for water by rounding off the peak on the consumption curve and it will also give our consumers more blue grass and less crab grass in their lawns.

This discussion has been an effort to illustrate three of many methods which may be used to meet the demands created by air-conditioning; first—that the proper use of elevated storage will enable the present distribution systems to handle additional load; second—that re-pump storage supplies will allow existing plants and transmission mains to operate at a more uniform rate and therefore handle considerably more total daily pumpage; and third—that the promise of additional peak load due to air-conditioning makes it urgent that steps be taken to reduce the present undesirable peak water consumption.

AIR-CONDITIONING IN THE CITY OF CHICAGO

Report of Investigations Carried on during 1937

By Loran D. Gayton

The study of air-conditioning as affecting the water consumption and the peak load demands on the Chicago water supply system, which was started during 1936, was continued throughout the year 1937, and is expected to be even more extensively pursued during 1938. In the following paper we gave the results of the study to December 31, 1937.

The figures show quite clearly the present trend as regards the installation of air-conditioning equipment in the City of Chicago.

Figure 1 shows the installation of air-conditioning equipment in the City of Chicago as a whole, and in the downtown area from 1932 to December 31, 1937. This indicates quite clearly that the rate of installation has increased from year to year.

Figure 2 shows the tonnage of air-conditioning installations in the entire City of Chicago, classified as to usage.

During the past five years the total number of installations in the downtown area has been between 25 and 33 per cent of the total for the entire city and the tonnage for the downtown area has been between 25 and 38 per cent of the total for the entire city. Theatres as a group still lead in total tonnage. They were probably the first to go in extensively for air-conditioning. Practically all of the theatres in the downtown area have been air-conditioned since 1932, and since that time there has been practically a steady increase in both number and tonnage as the theatres in the outlying districts became air-conditioned.

As regards offices, stores, and restaurants, there has been, since 1935, a large increase each year in both the number of installations and tonnage over that of the previous year. The tonnage of each of these three classes will undoubtedly exceed that of the theatres

A paper presented at the New Orleans convention, April, 1938, by Loran D. Gayton, City Engineer, Chicago, Illinois.

by the year 1940. The installation of air-conditioning in small stores, especially around a prominent business centers increased rapidly during 1936 and 1937.

FIGURE 1

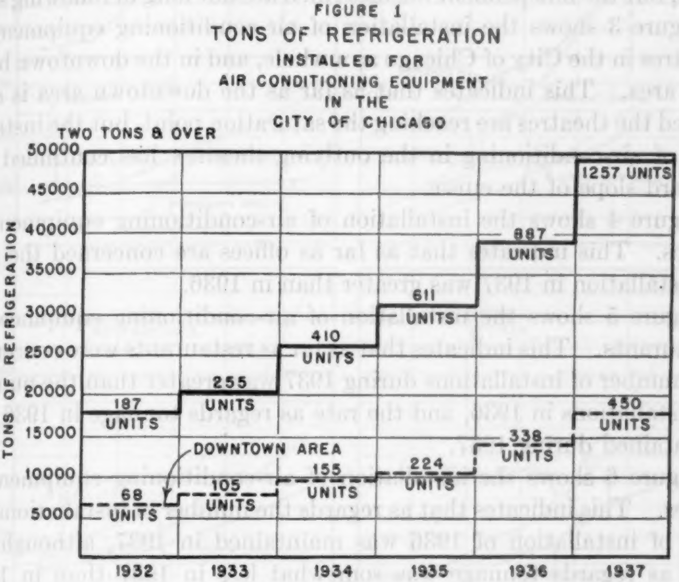
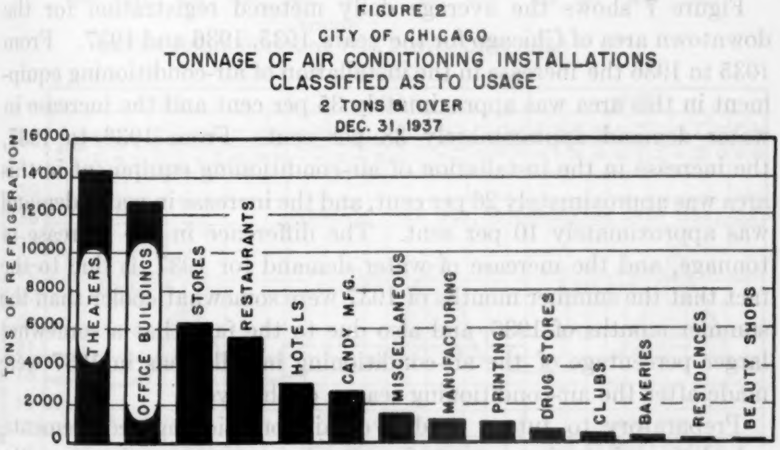


FIGURE 2



In the outlying business centers, shoe stores, dress shops, and restaurants are among the first to air-condition their premises, and it will be noted that when one store of a certain kind installs air-

conditioning, competitors in the same neighborhood will, of necessity, follow suit. In the outlying business districts which movement to air-conditioning is usually started by one of the chain store organizations, but the independent business men are not long in following suit.

Figure 3 shows the installation of air-conditioning equipment in theatres in the City of Chicago as a whole, and in the downtown business area. This indicates that as far as the downtown area is concerned the theatres are reaching the saturation point, but the installation of air-conditioning in the outlying theatres has continued the upward slope of the curve.

Figure 4 shows the installation of air-conditioning equipment in offices. This indicates that as far as offices are concerned the rate of installation in 1937 was greater than in 1936.

Figure 5 shows the installation of air-conditioning equipment in restaurants. This indicates that as far as restaurants were concerned the number of installations during 1937 was greater than the number of installations in 1936, and the rate as regards tonnage in 1936 was maintained during 1937.

Figure 6 shows the installation of air-conditioning equipment in stores. This indicates that as regards the number of installations the rate of installation of 1936 was maintained in 1937, although the rate as regards tonnage was somewhat less in 1937 than in 1936.

Figure 7 shows the average daily metered registration for the downtown area of Chicago for the years 1935, 1936 and 1937. From 1935 to 1936 the increase in the installation of air-conditioning equipment in this area was approximately 35 per cent and the increase in water demand approximately 38 per cent. From 1936 to 1937, the increase in the installation of air-conditioning equipment in this area was approximately 26 per cent, and the increase in water demand was approximately 10 per cent. The difference in the increase of tonnage, and the increase of water demand for 1937, is due to the fact that the summer months of 1937 were somewhat cooler than the summer months of 1936, and also due to the fact that a somewhat larger percentage of the air-conditioning installations in 1937 were made after the air-conditioning season of that year.

Preparatory to future studies of air-conditioning requirements, calculations have been made for the downtown area between the Chicago river on the north and west, and Van Buren Street on the south. The area has been divided into blocks, and each block studied as a unit. A separate drawing has been made for each block, showing

CITY OF CHICAGO
AIR CONDITIONING EQUIPMENT INSTALLATIONS — 2 TONS & OVER

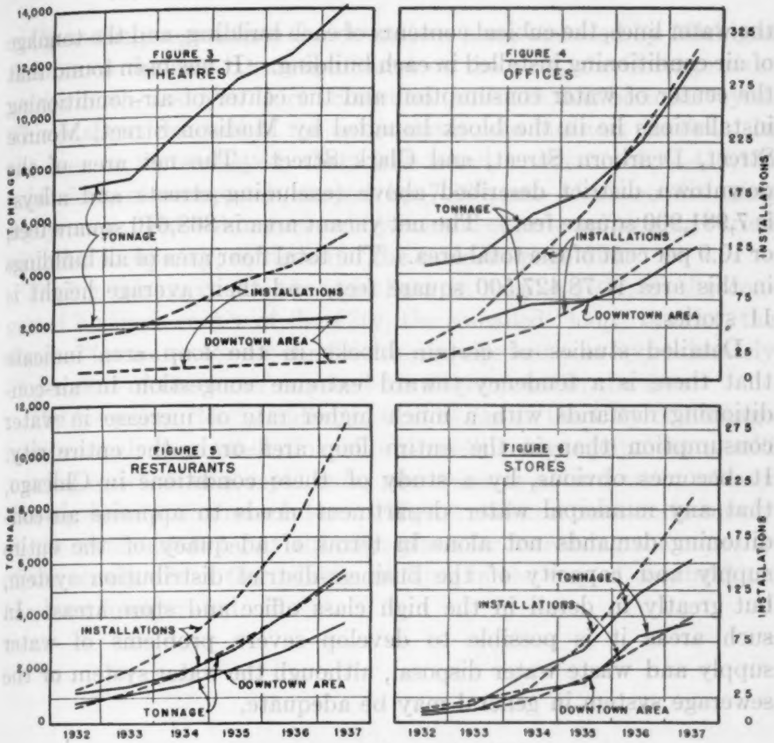
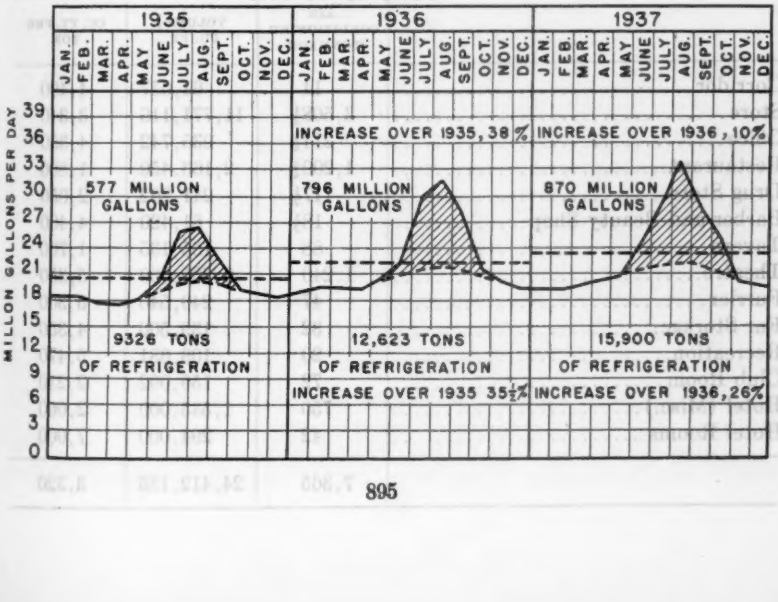


FIGURE 7
METER REGISTRATIONS FOR DOWNTOWN AREA
CITY OF CHICAGO



the water lines, the cubical contents of each building, and the tonnage of air conditioning installed in each building. It has been found that the center of water consumption and the center of air-conditioning installations lie in the block bounded by Madison Street, Monroe Street, Dearborn Street, and Clark Street. The net area of the downtown district described above (excluding streets and alleys) is 7,981,900 square feet. The net vacant area is 868,640 square feet, or 10.9 per cent of the total area. The total floor area of all buildings in this area is 78,427,500 square feet, and their average height is 11 stories.

Detailed studies of certain blocks in the loop area indicate that there is a tendency toward extreme congestion in air-conditioning demands with a much higher rate of increase in water consumption than in the entire loop area or in the entire city. It becomes obvious, by a study of these conditions in Chicago, that any municipal water department needs to appraise air-conditioning demands not alone in terms of adequacy of the entire supply and capacity of the business-district distribution system, but greatly in detail in the high class office and store areas. In such areas it is possible to develop severe problems of water supply and waste water disposal, although the water system or the sewerage system in general may be adequate.

1938 Air-Conditioning Survey

Downtown Area (East of Dearborn St.)

	AIR CONDITIONING TONNAGE	VOLUME, CU. FT.	CU. FT. PER TON
Corridor	14	61,657	4,400
Store	3,508½	11,771,116	3,340
Office	214¾	935,742	4,350
Restaurant	1,200¾	2,163,450	1,800
Drug Store	117½	241,202	2,050
Barber and Beauty Shop	18½	81,420	4,400
Tavern	88	155,135	1,760
Theatre	1,240	6,505,600	5,350
Furrier	47	249,540	5,300
Fur Storage	32	139,500	4,350
Recreation	20	109,681	5,470
Club Room	72	159,092	2,210
Hotel (Misc.)	750	1,545,000	2,060
Hotel Rooms	42	294,000	7,000
	7,365	24,412,135	3,320

Up to the present time the downtown area, bounded by Michigan Avenue on the east, Dearborn Street on the west, the Chicago river on the north, and Van Buren Street on the south, has been surveyed. This is about one-half of the entire downtown business district. In the area so far surveyed, there was found a volume of 24,412,135 cubic feet, of occupancy, served by 7,365 tons of air-conditioning equipment. The volume served by one ton of air-conditioning varied with the occupancy, as shown in the table on page 896.

During the maximum demand hour in August 1937, in the congested business center of the City, the so-called "loop" district, the demand for water for air-conditioning equipment was approximately 31 per cent of the water required for all purposes in the area.

The foregoing clearly indicates that as far as the City of Chicago is concerned, the installation of air-conditioning equipment is still moving forward at a rapid rate, and there is no indication of any slowing down in the near future. We are still in a position to supply all the water needed, but although plans for increasing the capacity of the sewers are in the making, nothing in the way of construction has been inaugurated.

ACCOUNTING IN SMALL WATER PLANTS

By F. R. Mills

In considering the subject of accounting in any business, one is immediately confronted with two distinct and mutually antagonistic viewpoints. On the one hand we have the old, shall we say "family," method of accounting which can best be described by recounting the story of Mary Brown who, in keeping her household expense book, wrote down, "Received from Henry, $100.—spent it all." On the other, there is a large and apparently growing school of thought which keeps so many interlocking and excessively detailed records that it may almost be said that the system runs the business—into the ground.

Our problem is to steer a well-marked course between these extremes. Naturally local conditions, legislative enactments and the provisions of many local charters may require an item of detail of some character not generally known, but in the main, Florida charters for cities, all special acts of the legislature, are remarkably broad and go into little detail concerning the operations of the municipal utilities. For example, in the case of Daytona Beach, in a charter act requiring ninety pages of small print, the only reference directly to the Utilities Department, is one clause in one section which says "That the City Commission shall have power . . . to provide for the public supply of pure water for all purposes of the city and its inhabitants . . . and to prescribe, regulate and control rates for furnishing water to the inhabitants of the city. . . ."

Good organization, in any business, requires the realization, and then the action upon that realization, that the business exists for the purpose of rendering a definite service, and can best do that by proper analysis and classification of functions. No utility is too small to carry this classification into effect, although, to be sure, in small water plants, there is necessarily some consolidation of functions. In Daytona Beach, the department under my direction is divided, not only on paper, but in actual day to day operation, into three

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A paper presented at the Florida Section meeting, May, 1938, by F. R. Mills, Director, Utilities Department, Daytona Beach, Florida.

distinct, working divisions: (1) Production, (2) Distribution, and (3) Accounting and Administration.

Although these divisions are, in a measure, self-explanatory, let us examine briefly how they may and should exist in any well-organized department. Production, which would include procurement of supply, involves the operation of the production plant, wells, pumps, chemical supply, feeders and all other production machinery. In Daytona Beach, that division is under the control of a Chief Operator who, in our case, is also plant chemist and bacteriologist. It seems to be a most logical arrangement, because, in a larger plant, or as business grows, this position can be divided and even sub-divided; in a smaller plant, the director himself might fill the position. Under the Chief Operator we have seven full-time operators, making it possible to employ two on each of three eight-hour shifts, and the seventh acting as relief for every other operator. Accordingly each operator works 48 hours a week, and has one full day off. Also the Chief Operator is able to substitute for any operator in case of emergency, or to re-arrange shifts to take care of absences on account of illness or for other cause. Under Production we carry a full-time maintenance man, who is also being trained as an operator for emergency work.

The division of Distribution is also self-explanatory. We operate this division under the direction of a Service Foreman, who, again, is answerable to the department head. His own duties include the care of the materials store-room, issuing requisitions for the purchase of supplies, assignment of work orders for new connections, for the placing and removal of meters, etc., all such orders originating at the accounting office in City Hall. He keeps a daily payroll distribution sheet assigning the three drivers and their crews and charging their payrolls daily to the jobs done. He personally investigates customer service complaints when a "tough nut" crops up, and, if too tough, turns the complaint over to the department head. His function is clear and his place unmistakable, yet he can be enlarged by the addition of assistants, or, in a small plant, he may, of course, be the department head himself.

One peculiarity of our Daytona Beach system is the operation of a stand-by plant, which is normally out of service and kept ready to run on short notice. In classification, when not operating, it comes under the direction of the Distribution division, and certain materials and supplies are warehoused at that point. When in operation,

however, it changes classification to the Production division and then comes logically under the direction of the Chief Operator.

Accounting and Administration is, of course, the most readily recognizable department in any utility, and, from the viewpoint of most superintendents, it is merely a necessary evil anyway. In Daytona Beach this department has undergone a complete reorganization in the past three or four years, and it is the accomplishments of this particular division that I wish to point out in some detail, not wishing to write an accounting manual, but to recount some of our discoveries and rediscoveries in the hope that they may be useful elsewhere or applicable under somewhat different conditions.

Essentially the work of the Accounting division is simple. It is designed to get the money. Yet we have found that there are comparatively—notice the comparative—painless ways of doing this. This involves some detail, which I shall make as brief and pointed as possible.

First there is the necessity of creating the proper relationship between the customer and the department from the start. We operate on a contractual basis with each consumer, under general rules and regulations applicable to all, and require a "Connect" order, signed by the customer applying for service (Exhibit A), and a deposit based, in the case of straight residential consumers, on the size of the service connection. We have currently 5,000 service connections, of which almost the entire number are active at the peak winter and summer resort seasons. The original of the "Connect" order, when worked, slips into a Kardex file pocket arranged by street and number to take in the entire city. From that point on, the account becomes a number, and meter book sheet, ledger sheet and bill, all made up from the same Addressograph plate from this "Connect" order, are arranged numerically.

The Kardex file referred to has a permanent 5 x 8 card (Exhibit B) on which particulars concerning this particular customer are filled in, first across the bottom, visible edge, then up the sheet line by line (as one customer succeeds another at the address), giving a permanent record of occupancy, meter numbers, makes, deposits and names. A customer or prospective customer has merely to give his address, and the entire accounting system is keyed to a number corresponding to this address in this permanent file. In passing it might be of interest to point out that we have worked out a system of assigning numbers similar to the Dewey decimal classification

CONNECT Install — Tap No. 150

Street: Main — House No.: 5050

Name: John Doe

Mailing Address: 452 Park St. — Size Tap: 3/4

Meter Make and Number	Reading	Ordered	Wanted
TRI-246890	120		At Once

Worked By	Date	Appl. Clerk	Book	Plate
P.O.	12/3/37	A.P.E.		

The undersigned requests the CITY OF DAYTONA BEACH to furnish WATER service located and described above and agrees to receive and pay for same in accordance with rules and regulations of the CITY OF DAYTONA BEACH covering such service.

1m 12-37

Signed x John Doe

By.............................

Deposit No.: 50678

Deposit: 5.00 — Name:

EXHIBIT A

Memo.	Meter No.	Make	In	Out	Deposit	Name

Location		Tap No.	Meter No.	Make	In	Out	Deposit	Name
Main	5050	150	246890	Tri	12-3-37		5.00	Doe, John

EXHIBIT B

system of libraries, so that an account between, say, 150 and 151 can be set up as 150.5 another as 150.7, and so on.

For many years we billed consumers quarterly, because everybody

else did. We gradually developed a modification in billing by zones so that the work of the cashier's office as well as that of the readers and billers was smoothed out to some extent. This gave us, in effect, continuous monthly reading but on a three-months basis. We weighed for some time the advisability of changing further to continuous monthly billing of all accounts, but the immediate necessity for so doing was a change in our rate structure which the Public Works Administration required in financing our new plant project. To make, then, a virtue of necessity, we changed our billing method at the same time we changed the rate, thus obscuring the change to some extent. Our former quarterly minimum bill, for example was (for a $\frac{5}{8}$ or $\frac{3}{4}$-inch service) $1.25 (as service charge), no discount plus 20¢ per thousand gallons. In making two moves at once, the new monthly bill, minimum, became $1.00 gross, 90¢ net, which allowed 2,000 gallons. We had no particular "rise" out of this class of accounts, which comprised at that time 29 per cent of all accounts, all of the complaint coming from those higher up the consumption brackets where the 30¢ per thousand against the former 20¢ began to hurt. Still, monthly billing, in a manner of speaking, took the curse off and, after the difficulties of the change had worn away, these two facts were outstanding: (1) The change itself, aside from the increase of rate, actually produced greater revenue by immediately improving or speeding up collections, partly due, no doubt, to the cash discount, by catching excessive bills before they had gone too far, and by keeping many accounts of a "doubtful" nature within the required deposit, and (2) The change produced less than expected expense, because the new system required only one additional meter reader and one clerk in the billing office to handle three times as many accounts each month, because their billing velocity had thus been increased. It is, accordingly, interesting to observe that the change produced not only greater gross revenue, but actually increased net revenue in almost the same proportion, irrespective of rates charged.

A well-developed reading and billing system is vital in monthly billing. It was necessary for us to buy a new billing machine, and after considerable investigation we purchased a Burroughs bill and ledger machine of the most modern type—a machine which prints bill and stub and ledger sheet for continuous record of the account, in one operation, and takes off at the same time a tally-sheet or journal sheet of all billings. Two or three features of this machine and its

application are worthy of special mention. The meter readers bringing in a completed book at the close of business on one day, and taking the next on schedule, leave a record of current readings for that day. One of the clerks computes, in the meter book itself, the net and gross charges for the accounts involved by means of tables on which it is merely necessary to find the amount consumed. The book is then placed in a rack at the left of the biller at the machine, who has, at his right the ledger tray containing that group of accounts and a stack of previously addressographed bills. The biller drops the similarly numbered bill and ledger sheet (Exhibit C) into the machine, both going to bottom stops which hold them in proper position. The new meter reading is first set up on the machine, and, when the motor bar is struck, the machine closes its carriage automatically and prints the new meter reading, together with the date, on the right hand edge of the ledger sheets, reverses and prints it again on the left edge of the bill proper (Exhibit D). The biller then sets up the previous reading, strikes the motor bar again, the previous reading is printed on the bill only. He then sets up the calculated consumption, net, and gross, from the meter book sheet and strikes the motor bar again. If his deduction showing consumption is correct, the machine then prints consumption, "Water," net and gross, both on bill and stub. If his pre-calculated consumption is not the difference between the present and previous readings, the machine refuses to print until correction is made.

This feature, together with the automatic date printer and the carbon copy of all bills supplied by the journal strip, is an outstanding safeguard in billing, as many of you know. The journal strip, at the close of the day's billing, will carry the total of every billing classification, total arrears carried onto current bills, and will also show the total "Finals" billed that day, which may be billed right amidst the "current" book with no difficulty merely by dropping a bill and ledger sheet into the machine and striking the "Final" bill control. This strip also shows the total consumption billed, which is, of course, a most important record even though, accumulated as it is over a thirty or thirty-one day period other than a calendar month, it is not a safe figure to use on calculations of too short range.

Let us return to our mythical customer, who signed the "Connect" order on December 3, 1937, for 5050 Main St., tap No. 150. His original order, after being worked by "P. O." on the same date, had a meter book sheet (Exhibit E) inserted in the proper book, had an

150
JOHN DOE,
5050 MAIN ST.,
CITY

38

DEPOSIT $ 5 NO. 50678

NAME ✓

	ITEM	WATER USED	NET	GROSS	CREDITS DATE	CREDITS CODE	CREDITS AMOUNT	READINGS DATE	READINGS READING
JAN.	WATER-	2	90	1 00				JAN 1	122
FEB.	MINIMUM ARREARS		90 1 00 1 90	1 00 1 00 2 00DUE	CREDITS FEB 25	PAID	300	FEB 1	122
MAR.	WATER- CREDITS	3	1 17 1 00 17	1 30 1 00- 30DUE	CREDITS MAR 25	PAID	.30	MAR 1	Credit 1.00 125 NO BALANCE
APR.	WATER-	2	90	1 00				APR 1	127
MAY	FINAL- ARREARS CREDITS	3	1 17 1 00 5 00 2 83	1 30 1 00 5 00- 2 70CR				MAY 1	130
JUNE									

EXHIBIT C

addressograph plate made and properly filed, after stamping a new ledger sheet, and now he has his January 1 meter reading, from which his bill (see Exhibit D) and ledger sheet have been made up. He

had until January 13 to discount this bill, but failed to pay it all; accordingly when his February 1 reading comes in, he has a new bill, a minimum charge showing no consumption, to which must be added the gross amount of his unpaid January bill. This is accomplished easily on the machine by using a separate motor bar, which returns the carriage to the billing point after completing the current billing, permitting "Arrears" to be added, and furnishing a net and gross total on his February bill, stub and ledger sheet.

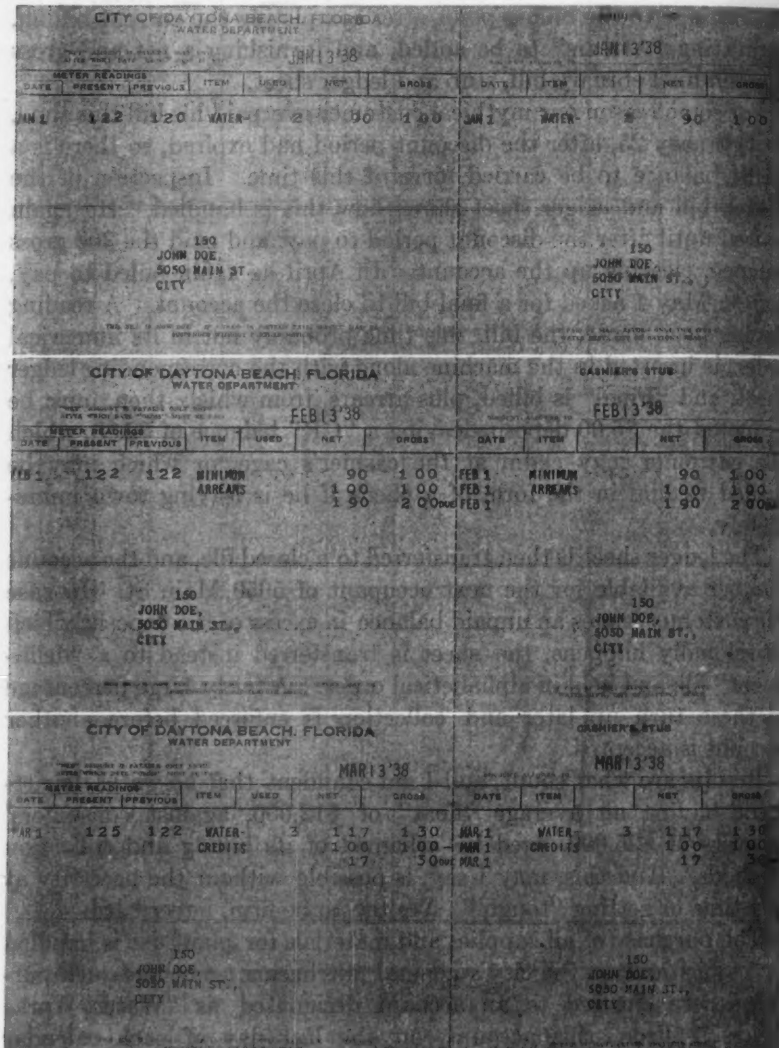
For some reason our mythical customer overpaid his bill this time, on February 25, after the discount period had expired, so there is a credit balance to be carried forward this time. Inspection of the March bill and ledger sheet shows how this is handled. He again waited until after the discount period to pay, and paid the 30¢ gross balance, clearing up the account. In April he again failed to pay, and on May 1 asked for a final bill to close the account. A reading having been made, the bill, this time probably not in its numerical order, is inserted in the machine along with the corresponding ledger sheet, and "Final" is billed, plus arrears, from which, then, must be deducted the $5.00 deposit, leaving a "CR" balance of $2.83, which the customer may claim at the cashier's cage, or which may be mailed to him in the form of a check if he is leaving town immediately.

The ledger sheet is then transferred to a closed file, and the account number available for the next occupant of 5050 Main St. In case the customer leaves an unpaid balance in excess of the deposit, which occasionally happens, the sheet is transferred instead to a "delinquent" file and held in alphabetical order. A fairly large percentage of these turn up later and collection is enforced before another account is accepted.

Results are what count, and I am confident that no water department having an average "float" of $12,000, against consumers' deposits of $25,000, need be ashamed of its billing and collection methods. And this, may I say, is possible without the necessity at any time of getting "tough." We try to be firm, never hard.

The purchase of all supplies and materials for plant use is handled by requisitions on the city's general purchasing agent and such purchases are charged to an account designated as "Water Works Stores." From this account, on the last day of each calendar month, the Chief Operator authorizes the charge of an exact quantity of lime, soda ash, alum, fuel oil, chlorine, etc., by accumulation

of the figures on the daily report sheets thus, in effect, getting a three-way check—amount apparently fed by the machines against amount apparently fed in so many hours run against amount actually left on hand in the warehouse. Ordinary care in keeping these records


CITY OF DAYTONA BEACH, FLORIDA
WATER DEPARTMENT
JAN 13 '38

METER READINGS DATE	PRESENT	PREVIOUS	ITEM	USED	NET	GROSS
JAN 1	122	120	WATER-	2	90	1 00

150
JOHN DOE,
5050 MAIN ST.,
CITY

DATE	ITEM		NET	GROSS
JAN 1	WATER-	2	90	1 00

150
JOHN DOE,
5050 MAIN ST.,
CITY

CITY OF DAYTONA BEACH, FLORIDA
WATER DEPARTMENT
FEB 13 '38

METER READINGS DATE	PRESENT	PREVIOUS	ITEM	USED	NET	GROSS
FEB 1	122	122	MINIMUM		90	1 00
			ARREARS		1 00	1 00
					1 90	2 00 DUE

150
JOHN DOE,
5050 MAIN ST.,
CITY

CASHIER'S STUB
FEB 13 '38

DATE	ITEM		NET	GROSS
FEB 1	MINIMUM		90	1 00
FEB 1	ARREARS		1 00	1 00
FEB 1			1 90	2 00 DUE

150
JOHN DOE,
5050 MAIN ST.,
CITY

CITY OF DAYTONA BEACH, FLORIDA
WATER DEPARTMENT
MAR 13 '38

METER READINGS DATE	PRESENT	PREVIOUS	ITEM	USED	NET	GROSS
MAR 1	125	122	WATER-	3	1 17	1 30
			CREDITS		1 00	1 00-
					17	30 DUE

150
JOHN DOE,
5050 MAIN ST.,
CITY

CASHIER'S STUB
MAR 13 '38

DATE	ITEM		NET	GROSS
MAR 1	WATER-	3	1 17	1 30
MAR 1	CREDITS		1 00	1 00
MAR 1			17	30

150
JOHN DOE,
5050 MAIN ST.,
CITY

EXHIBIT D

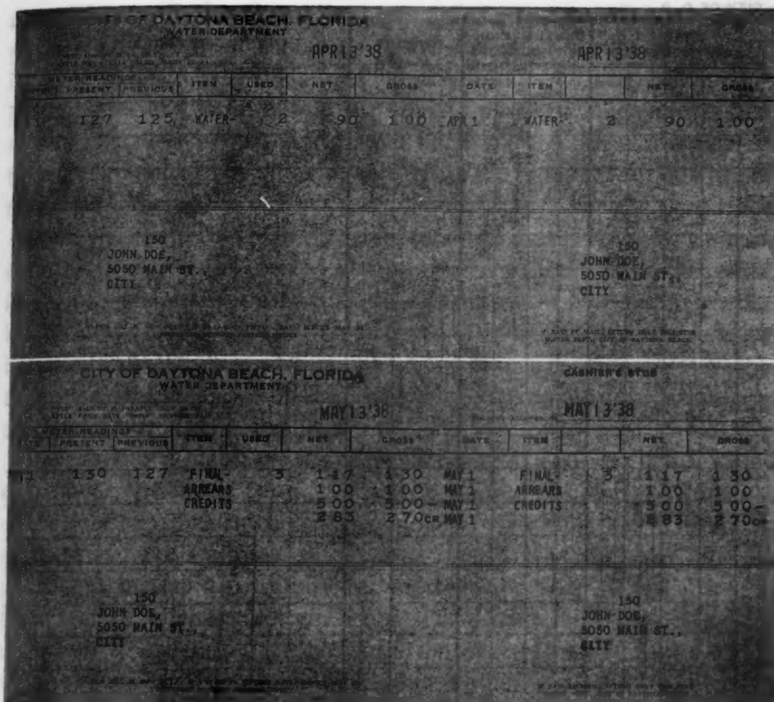

CITY OF DAYTONA BEACH, FLORIDA
WATER DEPARTMENT
APR 13 '38
APR 13 '38
127 125 WATER 2 .90 1.00 APR 1 WATER 2 .90 1.00
150
JOHN DOE,
5050 MAIN ST.,
CITY
150
JOHN DOE,
5050 MAIN ST.,
CITY
CITY OF DAYTONA BEACH, FLORIDA
WATER DEPARTMENT
CASHIER'S STUB
MAY 13 '38
MAY 13 '38
130 127 FINAL 3 1.17 1.30 MAY 1 FINAL 3 1.17 1.30
ARREARS 1.00 1.00 MAY 1 ARREARS 1.00 1.00
CREDITS 5.00 5.00- MAY 1 CREDITS 5.00 5.00-
2.83 2.70CR MAY 1 2.83 2.70CR
150
JOHN DOE,
5050 MAIN ST.,
CITY
150
JOHN DOE,
5050 MAIN ST.,
CITY

Exhibit D

makes it possible to confine to a calendar month the direct expenses of operation for that month, thus carrying cost accounting, without any fret or tears, into an exceedingly practical application. Under ordinary plant methods which we previously followed, a carload of alum, for instance, made a hump in the expense for chemicals in whatever month it was billed yet lasted for several months. Now materials, supplies and meters are all carried as "on hand" until actually consumed or placed into definite service, at which time they are "charged out" to the purpose or job on which they are employed.

This is similarly true of line work, repairs, new connections and all other service work. The Service Foreman issues a numbered job order to the crew foreman in charge of a particular job, on which he lists not only the labor, but every piece of material which went into that job. These job orders, then, at the end of the month, become charges to various expense accounts or capital accounts depending on what type of work was done, and, at the same time, credits to

CITY OF D. B.

DATE	READING IN THOUSANDS	CONSUMPTION IN THOUSANDS	AMOUNT	REMARKS
Jan.				
Dec.				
Nov.				
Oct.				
Sept.				
Aug.				
July				
June				
May 1	130	3	1.17 + 1.30	Final 5/1/38
Apr. 1	127	2	90 + 1.00	
Mar. 1	125	3	1.17 + 1.30	
Feb. 1	122	—	90 + 1.00	
Jan. 1	122	2	90 + 1.00	
Dec. 3	120.000			
Nov.				
Oct.				
Sept.				
Aug.				
July				
June				
May				
Apr.				
Mar.				
Feb.				
Jan.				

SERVICE CHARGE $\boxed{.40}$ Per Month

TAP NO.	SIZE	MAKE	DATE OF Conn.	DATE OF Disconn.	DATE OF Removed	METER NO.
						4
						3
						2
150	3/4"	Tri	12/3/37			1 246890

NAME OF SUCCEEDING CONSUMER

NAME	
5	
4	
3	
2	
1•	John Doe

ADDRESS: 5050 Main St.

DEPOSIT

	Date	Amount
5		
4		
3		
2		
1•	12-3-37	5 00

DEPOSIT

	Transfered	Applied
5		
4		
3		
2		
1•		

EXHIBIT E

the "Water Works Stores" account for the materials used. A physical inventory of the stores (semi-annually) serves to keep the books in balance with the stores value actually on hand. The city's general auditor then makes a suitable adjustment, once a year, and in practice these adjustments have been very small, averaging less than 1 per cent of the value of the materials handled. The system, then, pays for itself.

With reference particularly to meters and meter records, we have adapted to our requirements here a system which I have picked up in various technical journals at different times. Our requirements, let me say, differ somewhat from those of more stable communities, because the business of meters in and out here is considerably greater than, for instance, would be true of Jacksonville or Tampa, on account of our large seasonal population.

In removing a meter we supply a 4 x 6 tag on a rubber band, which snaps over the meter head, giving the service number and location of the service from which it was removed. (Exhibit F). Inasmuch as these removals almost all occur at one time of the year, and no additional meters are usually required during this off-peak period, these meters, *after testing*, are benched and held, with tags attached, until service orders for their restoration begin to come in, at which time the same meter is re-installed so far as this is possible. We have experimented with not removing these meters at all, but lacking a suitable method of accurately testing them "in situ" we have, in spite of the labor involved, generally considered it preferable to take them out, test, and bench ready for re-installation. During May and early June annually we take out and put on the shelf between three and four hundred meters in this classification.

The same identification tag, in case the meter tests "off", or needs repairs for any reason, serves as a record of repairs made. Convenient spaces are provided for inserting, with simply a check-mark, the principal repairs required, and these cards, taken off the meters when re-installed, come to the Service Foreman, who posts them to his permanent meter record file and records repair cost in such a way that service records of different makes of meters and under differing conditions may be at least approximated. Of course damage apparently caused by hot water, or other damage outside the control of the department, is identified and, insofar as possible, collected from the person responsible. I might add that this is negligible here.

REPAIRS MADE

....

....

Lid ( )	Register Box ( )	Glass ( )
Glass Retainer ( )		Glass Gasket ( )
Register ( )	Gears ( )	Spindle ( )
Disc ( )	Disc Chamber ( )	Packg Nut ( )
Case ( )	Case Gasket ( )	Case Bolts ( )

Date.................................... By....................................

Meter No.................................... Make....................................

FROM Tap. No.............................. Date..............................193....

Address ....

TEST REPORT

		Lbs.	Slow	Fast	%
1-4	....	....	....	....	....
1-2	....	....	....	....	....
Full	....	....	....	....	....

REPORT TO

....

Date.................................... By....................................

500 10-37

EXHIBIT F

DAYTONA BEACH WATER TREATMENT PLANT

DAILY REPORT

		Operator	Helper
WEATHER	SHIFT 1		
	2		
Temp. 8 A. M. Noon 8 P. M.	3		

PRESSURE PUMPS					PRESSURE PUMPS				
Pump No.	On	Off	Hours	Min.	Pump No.	On	Off	Hours	Min.
					RAW WATER PUMPS				
					Rate				

RAW WATER METER		OUTPUT METER		POWER METERS			
				METER NO.	PRESENT READING	PREVIOUS READING	KILOWATTS USED
		Present Reading		1			
Present Reading		Previous Reading		2			
Previous Reading		Gallons Pumped		3			
				4			
Gallons Pumped		Booster Sta.		5			

FILTER OPERATION	No. 1	No. 2	No. 3	No. 4
Time of Washing Day Hour				
Time of Previous Washing Day Hour				
Length of Filter Run, Hours				
Rate of Flow Before Washing				
Loss of Head Before Washing				
Minutes Washed				
Rate of Wash. Gal/Min.				
Total Wash Water Used				

CHLORINE CONSUMPTION	4 A. M.	8 A. M.	12 Noon	4 P. M.	8 P. M.	12 M. N.
Present Weight of Cylinder						
Chlorine Fed in 4-Hour Period, Lbs.						
Tare of Cylinder, Lbs.						
Chlorine Remaining in Cylinder, Lbs.						
Total Chlorine Fed on Shift, Lbs.						
Chlorinator Setting						
Slaker Temp.						
Lime/Water Setting						
Clear Well Level						

Fire Alarms:

Emergency Calls:

Maintenance:

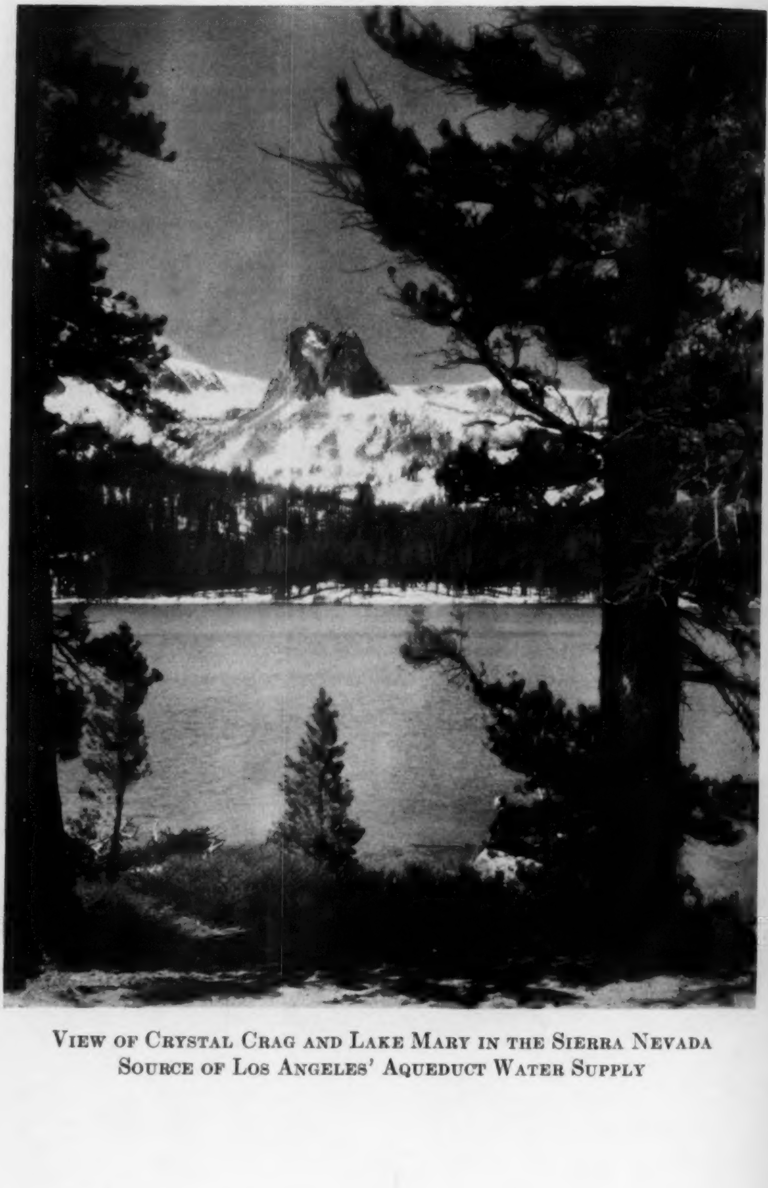
Date ....

[illegible]

In plant operation, we have evolved a daily report sheet (Exhibit G) for operators which, in addition to the usual statistical information, provides data upon which definite daily costs of operation may be determined. On the plant switchboard are five watt-hour meters on the principal power circuits, which are read and recorded at midnight daily. Not only can we determine from day to day the number of kilowatts required to pump in raw water and pump out treated water, but we can also by a simple determination of the ratio of kilowatts to million gallons daily check positively the relative efficiency not only of individual pumps but of the entire pumping group during varying load conditions. On the reverse of this sheet are spaces for recording routine determinations (made hourly by the operators themselves) of the results of the softening process.

On the Chief Operator's daily report sheet, on which the detailed chemical determinations are recorded, space is provided for determination of the number of pounds of each chemical applied during that day. Naturally we do not develop all this information every day, but the basic facts are collected daily, and exact costs may be determined whenever any change in treatment is made, so that we are able at all times to determine our exact operating costs, because items of overhead and fixed charges remain practically constant and need be determined only monthly. None of these plant records is laborious to keep; all have been boiled down to what we consider essentials, and we do expect to make good use of all under varying operating conditions.

I have tried in this paper to give you a few very practical experiences and developments. I have not attempted to write an accounting manual, as all of you are faced with different conditions requiring as much different treatment of records as of the water itself. I am a great believer in organization, and the development of clear lines of responsibility, and in the enforcement of that responsibility upon the organization. And organization is personnel; hence we return to the clear vision that while executive organization is indispensable, methods are never substitutes for men.



View of Crystal Crag and Lake Mary in the Sierra Nevada
Source of Los Angeles' Aqueduct Water Supply

BUSINESS PROCEDURE IN THE WATER SALES DIVISION

By Thad M. Erwin

This paper presents a discussion of the business methods and the actual financing procedure involved in connection with the furnishing of the various water services, installation of mains, and with whatever is found necessary in order to furnish the consumer with a satisfactory water service and an adequate water supply.

The regular business procedure in our Water Sales Division, in furnishing a water service satisfactory to the consumer and collecting monies for this service, is entirely in accordance with definite rules and regulations established by the Board of Water and Power Commissioners of the city of Los Angeles.

We know that good business procedure of any type requires that the charge for any service be governed by the cost of rendering such a service. In this day of rapidly advancing costs, automatically and necessarily attributable to the increasing cost of labor and material, the business of providing satisfactory service and establishing satisfactory and sufficient rates for all water consumed, demands a careful study of costs and revenues—in order to determine just what is adequate in the way of financing.

Our organization has just completed such a study of rates and of rules and regulations, and made the revisions that we have felt vitally necessary in order to improve and safeguard service and to secure adequate financial returns.

Financing as applied to the Water Sales Division may be classified under two headings—the installation of services and the related charges, which are made and collected by this division and will be explained first; and water rates, which are revised and approved by this division, but charged and collected by the Commercial Division. The subject of rates will be taken up later on in this article.

Los Angeles, with an area of 451 square miles, is the largest city in

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A paper presented before the Finance and Accounting Division during the New Orleans Convention, April, 1938, by Thad. M. Erwin, Water Sales Agent, Bureau of Water Works and Supply, Department of Water and Power, Los Angeles, California.

area in the world, and has an estimated population of 1,440,000 persons. Three hundred and forty-two square miles of this area are served by our Municipal Water Bureau; and this service requires more than four thousand miles of water mains, mostly cast iron, ranging in size from 4 inches to 78 inches in diameter. The average daily consumption is 225,000,000 gallons.

The rapid growth of this city is known to have been unprecedented. But we have been fortunate in that, as our population has grown by leaps and bounds, our engineers have been able to foresee this growth and take steps to provide a water supply adequate for the demands of such a population and such an area.

In the early days our water supply was obtained from the Los Angeles River. Some 25 years ago, after heavy drafts indicated that eventually this rapidly growing desert town would make no further growth because of the limited supply of water, our engineers brought an additional water supply from snow-covered mountains some 250 miles away. This water, conveyed through an aqueduct built over mountains and across deserts, furnishes about 77 per cent of our water supply while the remainder is obtained, by pumping, from the underground gravels.

Water from the aqueduct and river is delivered to eleven elevation zones ranging from sea level to approximately 1,400 feet above. There are numerous additional zones of elevation requiring pumping into small tanks and reservoirs. The highest elevation to which water is delivered is 1,720 feet above sea level. All water is metered, requiring 272,000 active services, exclusive of irrigation, with approximately 500 new services installed each month.

I mention these facts for the benefit of those who do not already know the unusual conditions to be met and conquered in this city that, without our abundant supply of water, would still be only a little town on the edge of a desert. It is these same conditions that control our rates and financing regulations.

All applications for new service, estimates of cost for complete water systems in new subdivisions, and arrangements for water main extensions, are handled by our Water Sales Division.

SERVICE CONNECTION CHARGES

Up to the time of revision of the rules and regulations, in January of this year, all service connections larger than two-inch had no definite price, but were installed at actual cost for labor and material.

It was discovered that by this method of procedure, much time was lost due to the fact that an individual inspection must be made in each case and an estimate furnished. The applicant then established satisfactory credit, or made a deposit on the estimated cost and signed the regular form of authority for billing, agreeing to accept billing as rendered within 15 days after installation, or when actual costs had been assembled.

In the new rules and regulations we have established a flat price for each size service up to 8-inch, so that now when a consumer makes application for any service up to 8-inch, we can quote him the exact cost of installation before he leaves the office.

Our installation charges for domestic, commercial, industrial, combined irrigation and domestic, and automatic fire sprinkler services are as follows:

Size of service connection	*Charge*
½-inch Flush Tank	$12.00
¾-inch	15.00
1-inch intermediate	18.00
1-inch full	24.00
1½-inch	30.00
2-inch	46.00
3-inch	125.00
4-inch	165.00
6-inch	195.00
8-inch and larger	At cost

These service connection installation charges include housing of meters and housing of detector check valves; but do not include meter deposit charges, detector check valve charges, or cost of installing pressure regulators where required.

The charges for intermittent irrigation service installations are as follows:

Size of service connection	*Charge*
1½-inch	$30.00
2-inch	46.00
3-inch	75.00
4-inch	90.00
6-inch and larger	At cost

Note: this charge does not include meter deposit or charge for control valve.

DETECTOR CHECK VALVES

On each new automatic fire sprinkler service connection, we set a check valve of a type approved by the National Board of Fire Underwriters and equip this valve with a by-pass meter that is read periodically; and the charge to the consumer for installing this detector check valve and by-pass meter is as follows:

Size of detector check valve	*Charge*
2-inch	$70.20
3-inch	83.70
4-inch	97.20
6-inch	135.00
8-inch	264.60
10-inch and larger	At cost

This charge is in addition to the service connection charge.

In addition to the monthly service connection charges, as shown in our ordinance, the regular domestic, commercial and industrial rates are charged for all water used for purposes other than fire extinguishing as recorded on the detector check valve by-pass meter. The Department, as it sees fit, may read any such by-pass meter either monthly, bi-monthly or quarterly, and render bills accordingly.

PRESSURE REGULATORS

All applicants for service are required to accept and agree to such conditions as exist under our current operating practice—and to hold the Department blameless for any damage arising from low or high pressure, fluctuations in pressure and/or interruptions of service.

When a consumer requests a reduction in water pressure, we install a pressure regulator, strainer, and relief valve, and regulate the pressure to suit the consumer, making the following charges:

Size of equipment	*Amount of charge*
½ or ¾ inch	$17.00
1-inch	19.00
1½-inch	38.00
2-inch	52.00

METER SETTING CHARGES AND DEPOSITS REQUIRED

We furnish and set meters of certain sizes without charge, (other than service connection charge for each such meter), on service con-

nections installed for domestic, commercial and industrial, and combined irrigation and domestic use. For any larger meter, the applicant is required to make a deposit.

The several sizes of meters that we set without charge (other than service connection charge) on each size of service, and the respective deposits required, are shown in the following table:

Domestic, commercial and industrial and combined irrigation and domestic service meters

SIZE OF SERVICE CONNECTION	SIZE OF METER REQUESTED AND AMOUNT OF DEPOSIT								
	⅝ × ¾"	¾ × 1"	1"	1½"	2"	3"	4"	6"	8"
¾"	*								
1"	*	*	$6						
1½"	*	*	$6	$21					
2"	*	*	*	$15	$32				
3"	*	*	*	*	$17	$97			
4"	*	*	*	*	*	$80	$175		
6"	*	*	*	*	*	$80	$175	$370	
8"	*	*	*	*	*	$80	$175	$370	$650

* No deposit required.

Intermittent irrigation service meters

SIZE OF METER	AMOUNT OF DEPOSIT	CHARGE FOR CONTROL VALVE*
1½"	$21.00	$3.50
2"	32.00	5.50
3"	51.00	9.50
4"	59.00	12.50
6"	91.00	At cost
8"	250.00	At cost

* Control valves are installed for the convenience of the consumer and for the protection of the meter, and installation is compulsory. The valve is installed on the outlet side of the meter, thus permitting the consumer to regulate the flow of water from the meter; installation and maintenance of this valve are at the consumer's expense.

REFUNDS OF DEPOSITS

When a deposit for a meter for domestic, commercial and industrial service has been made and the average monthly consumption of water through this meter is not less than the amount shown in the following table, for either (a) the first three years after the setting date of the

meter, or (b) for the second and third years after that date, 70 per cent of this deposit is subject to refund upon written application at any time after the expiration of three years from setting date.

Size of meter	*Average consumption in cu. ft. per month*
1-inch	14,400
1½-inch	21,600
2-inch	36,000
3-inch	64,800
4-inch	129,600
6-inch	216,000
8-inch	432,000

All refunds based on consumption are made to the original payor, or his assigns, and no refund on a meter deposit will be allowed if the required consumption does not occur within three years from the setting date of the meter as stated above. The above-stated quantities in cubic feet per month for the different sizes of meters amount to one-fourth the rated capacity of the respective meters for a four-hour continuous flow per day for thirty days. For example, where a charge has been made for the setting of a two-inch meter on a two-inch service connection and the average consumption equals or exceeds 36,000 cubic feet per month for twelve consecutive months after the meter has been set, a refund of 70 per cent of charge may be made. No refund of meter setting charges will be made if the meter has been in service more than two years; and no refund based on consumption will be allowed for a meter supplying any irrigation service.

STREET MAIN EXTENSION CHARGES

All property in the city of Los Angeles is subject to a street main assessment charge of eighty cents per front foot to cover the cost of installing water mains; and this charge must be paid before a service can be installed—even though the main is in the street.

INDIVIDUAL SERVICES

When a new service is ordered by a private individual, the district map is first checked to see if service is available there or if the main must be extended in order to install a service.

If there is no main in the street, an extension from the nearest existing main will be made on the basis of 200 feet for each active

consumer, providing the applicant pays his street main assessment charge of 80 cents per front foot for the property to be served, in addition to the regular service connection charge.

All intervening property is then marked on the district sheets or maps with a special symbol denoting that the street main assessment charge of 80 cents per front foot is due; and this assessment must be collected before an application for service connection can be accepted.

Where water main extensions are required in excess of 200 feet, a deposit of $1.60 per lineal foot must be made. This deposit minus 80 cents per front foot of the property frontage requiring service will be refunded to payor or his assigns only if and when street main assessment charges are collected from other consumers requiring service from this extension, and not otherwise.

However, any extension in excess of 200 feet may be made without such deposit provided funds are available and a survey by our Chief Engineer and General Manager shows that such an extension will yield an income from the sale of water, of at least 12½ per cent on the total investment in installing such extension in excess of 200 feet.

NEW SUBDIVISIONS

At the request of a subdivider of residential property, an estimate will be furnished on the cost of installing a complete water system, consisting of mains, service connections and fire hydrants to serve the entire tract. The main installed may be from six to twenty-four inch size, but must be adequate to furnish an ample water supply at all times. Streets must be down to subgrade and dedicated to public use before mains will be installed.

Our City Planning Commission recently prepared an ordinance, which was duly approved by the City Council, requiring subdividers to install all necessary mains and fire hydrants in any and all future tracts. Amounts paid for these mains and hydrants are not subject to refund.

Our estimate to the subdivider provides for piping of streets at $1.60 per lineal foot plus $100.00 each for fire hydrants; service connections are installed if desired. Fire hydrants are installed at each intersection, or ordinarily every 600 feet, at locations designated by the Los Angeles Fire Department. I might add here that the Fire Department pays us $3.00 per month per hydrant for maintenance and for water used from fire hydrants for fire extinguishing

purposes. We now have 20,625 fire hydrants installed for property protection.

Where abutting property is not the property of the subdivider, he is required to pay a deposit of 80 cents per front foot, and the full amount of the deposit is refunded to the payor or his assigns as the frontage tax is collected when application for new service is received. However, in cases where the property abutting the subdivision is of a character that would indicate that no service will ever be requested there, such deposit may at the option of our Chief Engineer and General Manager, be waived.

INDUSTRIAL TRACTS

When an estimate is requested for installation of a water system in an industrial district, an estimate is submitted, based on actual labor and material costs plus engineering supervision expense, as industrial property requires 8-inch and larger pipe in order to insure an adequate water supply at all times. The subdivider deposits the estimated cost and if the estimate is over the actual cost, the difference is refunded; and if the estimated cost is less than actual cost, the difference will be collected.

ACREAGE SUPPLY ASSESSMENT CHARGES

On applications for water in newly annexed territories, or territory not heretofore served, where water supply is from pumped system, or from gravity system where additional expense (for main distribution lines, pumping plants, reservoirs, etc.) is involved, the property owners must pay an additional charge called Acreage Supply Assessment charge. This charge is based on the total of this additional expense; and each piece of property is assessed its proportion of the cost for the entire acreage to be so supplied.

However, any populated area in the city requiring service, may be served by the installation of mains, services, hydrants, pumping plants, tanks, or reservoirs, without paying this assessment provided funds of the Bureau are available and a survey shows that the income from the sale of water will be greater than 12½ per cent of the total investment, and the operating charges will be less than 40 per cent of the gross income from the sale of this water.

Temporary services are installed for the benefit of contractors, motion picture companies, oil wells, etc., where there is a regular service of sufficient size available, but shut off and sealed because

not required to supply the property which it enters. These temporary services are granted for a six-months period, although an extension of this time may be permitted. A charge of $2.00 is made for arranging for each temporary service.

I should like to go on record here as being heartily in favor of a "ready-to-serve" charge advocated by many authorities on municipal water works. Necessarily, many miles of pipe are laid facing vacant property. The installation of this main increases the value of this property, but we derive no revenue from this portion of our investment. If a water tax of 25 or 50 cents a month could be applied to each of these vacant properties, it would increase our revenues and help us to distribute more evenly the water service charges.

REVISED WATER RATES

As previously stated, our rules and regulations governing the rendering of water service have very recently been revised to conform to changing conditions, changed policies and increased costs, and in anticipation of various and sundry contributing factors; and I think it will interest you to mention some of these revisions.

One very important revision was in connection with the cash deposit previously required on applications for water service. Formerly when the applicant did not own the property to be served, he was required to deposit a cash guarantee equal to the estimated amount of two months' water bills, such deposit to be not less than $3.00—this amount to be refunded when the consumer discontinued service at that location (provided all bills were paid in full). However, under our new rules effective last January, an applicant furnishes requested references, but is not required to make a cash deposit so long as his bills are met promptly. This eliminates a tremendous amount of book-keeping formerly necessary in connection with collecting, holding and refunding of cash deposits; and also does away with the feeling of resentment that often arises when the consumer is requested to make a cash deposit to guarantee his payment of bills. It is felt that the small percentage of losses from uncollected bills will be more than offset by the reduction in accounting costs.

Another important ruling is in connection with the size of service connection required when toilets are to be flushed by flush valves instead of flush tanks. When application is made for installation of a water service connection and meter, the applicant must state the number and type of toilets to be installed; and if flush valve type

are to be installed, the water pressure there must be ascertained and service connection installed in conformity with the following table:

SIZE OF SERVICE CONNECTION AND METER	NUMBER OF FLUSH VALVES	
	Pressure 45 lbs. or lower	Pressure over 45 lbs.
1-inch	1 to 2	1 to 3
1½-inch	3 to 5	4 to 7
2-inch	6 to 12	8 to 15
3-inch	13 to 30	16 to 40
4-inch	31 to 75	41 to 90
6-inch	Unlimited	Unlimited

The number of flush valves to be supplied from the different sizes of service connections and meters is based on the delivery through the meter at the curb; and the consumer's pipe from the meter to the inside of the building should not be of a size smaller than the service connection and meter.

Until about a year ago, the Bureau would allow only one water service to a building; but because of the increasing demand for individual services, it now allows as many connections as may be desired, provided it is paid the regular service installation charge for each service connection. For example, the owner of a business block consisting of a market, drug store and a cafe, with a hotel or apartments above these stores, may prefer to install separate services, thus relieving him of any responsibility for segregation of consumption and collecting the charge from each tenant.

WATER RATES

I previously mentioned our water rate revisions. We all want our water rates to be as low as they can reasonably be made, but with the question of "reasonable" rates comes a marked difference in opinion, according to the point of view from which the matter is considered.

In considering the adjustment of rates for the services of any public utility, popular judgment is usually based, perhaps naturally, on a comparison with similar rates in other localities. Such a comparison is also very frequently the sole basis of attempted rate regulation by local authorities. Where the conditions are essentially similar in the localities compared, the results may be equitable, but the mere comparison of rates, without taking into consideration, in

detail, the local physical conditions, may frequently lead to most unjust and unfair conclusions.

This is especially true in the adjustment of water rates, for the conditions which control the cost of this service vary so greatly with the quality of water supplied, the treatment considered necessary before distribution, the distance from which it may be brought, the height to which the water must be raised, and local conditions in the area to be served, so that in many cases the fair return for one system might be quite different from the return that might be equally fair for another.

Water rates must also be based upon a careful study, over a period of years, of the revenue, income, depreciation, and the increasing amount of funds needed for replacements and constantly increasing operating costs. These items, being variable, make a rate revision necessary at intervals. An adjustment, particularly if in an upward direction, is always attended by more or less discussion and controversy, and sometimes strains the relations existing between the utility and the consumer, and it is therefore highly desirable that there be as few changes in rate structures as practicable.

It is the policy of the Water Bureau to deliver water to the consumers at the lowest possible cost to them; and it was only after long and careful consideration from every angle that the organization decided to raise the water rates. Regardless of the upward trend of all financing, materials, labor and essentials of operation, we have increased our water rates only twice since 1920—once in 1925, and the recent increase effective January 1, 1938, when all rates were increased approximately 19 per cent.

DOMESTIC, COMMERCIAL AND INDUSTRIAL RATES

The block system is used in building up the water rates, there being five blocks for domestic, commercial and industrial use. The new rates are as follows:

Rates per 100 cubic feet	*Quantity consumed*
15.5 cents	—for the first 10,000 cubic feet
13.1 cents	—for the next 40,000 cubic feet
10.7 cents	—for the next 50,000 cubic feet
8.3 cents	—for the next 200,000 cubic feet
7.5 cents	—for all in excess of 300,000 cubic feet

All domestic, commercial and industrial water consumers must follow through these rate blocks, thus eliminating any possible charge of discrimination.

MINIMUM CHARGES

The minimum monthly charges for domestic, commercial and industrial service are as follows:

METER SIZE	CITY	COUNTY
⅝″, ¾″ and 1″	$1.19	$1.69
1½″	1.79	2.54
2″	2.38	3.38
3″	3.57	5.07
4″	4.76	6.76
6″	7.14	10.14
8″	9.52	13.52
10″	11.19	.....

Water is served to consumers outside the corporate limits of the city where property is contiguous to the city and mains already exist—or where trunk lines feeding other parts of the city cross county territory, or where we have acquired water lines. Under any of these conditions, service may be secured by payment of the regular 80 cents per front foot street main assessment charge, plus service connection charge and our special county water rate of 30 cents per hundred cubic feet for the first 500 cubic feet and 20 cents per hundred cubic feet for all water consumed in excess of that amount.

I believe the question of water rates to be charged outside the corporate limits of any city is one that every water works man deems to be quite a problem, in determining an equitable rate to be charged. True as it may be that some municipal plants supply users outside the city at the same rate as those inside the city, it is our contention that the citizens inside the city limits were taxed for payments on bonds to build the system, while those outside the city escaped this tax. For this reason the consumer outside the city naturally should pay a higher rate.

All water consumed in excess of these amounts is charged at 4.7 cents per hundred cubic feet, if gravity water; or, if pumped water, at 6.7 cents per hundred cubic feet.

COMBINATION IRRIGATION AND DOMESTIC MONTHLY MINIMUM CHARGES

SIZE OF SERVICE	MINIMUM CHARGE	AMOUNT OF WATER
¾" and 1"	$2.00	1300 cubic feet
1½" and 2"	2.90	1900 cubic feet
3"	3.55	2300 cubic feet
4"	4.80	3100 cubic feet

This type of service is granted only where the water is being used for the irrigation of agricultural, horticultural, or floricultural crops produced primarily for the market, or for the irrigation of crops produced primarily for the feeding of fowls and/or livestock which are being raised, or the products of which are being produced primarily for the market, on parcels of land consisting of one-half acre or more.

INTERMITTENT IRRIGATION

This type of service applies to water furnished solely for irrigation purposes on larger parcels of land, and is subject to the demands of domestic, commercial and industrial consumers and to rotation of service among other irrigation users. The rate charged, as provided in the City Ordinance, is 1.75 cents per 100 cubic feet for gravity flow water, or 3.8 cents per 100 cubic feet for pumped water—with a $2.00 minimum charge for each time the water is turned on. This is called "intermittent irrigation" in order to distinguish it from the combination domestic and irrigation service where the service is connected and available at all times. The average annual revenue for this type of service is $450,000.00.

CREDIT PROCEDURE

A new intermittent-irrigation consumer is required to call at our office for the purpose of establishing his credit. He is requested to sign a statement covering certain required facts, and his statements are verified to the best of our ability. From this signed statement we decide whether or not the consumer shall be required to pay cash in advance for water to be used, or be granted the privilege of payment by the month. Approximately 65 per cent of all irrigation consumers are on a 30-day basis.

The cash customer is required, at the time of ordering water, to deposit an amount supposedly sufficient to cover the amount of water being ordered. In the event that he needs more water than he

has ordered, it will be necessary for him to make an additional deposit. Our average loss because of inability to collect irrigation accounts is less than 3 per cent.

SERVICE PROCEDURE

It may interest you to know how this type of service is installed and used. If the service is to be a 6-inch service, we tap the main and install a 6-inch main gate; and run a 6-inch pipe to the property line, where a main case or irrigation pot is installed with a 6-inch gate valve on either side for control of water. When the consumer orders water for a certain time, the "zanjero" (or water over-seer) installs a propeller and gear train in the main case, takes a meter statement, and leaves a notice for the consumer to turn on the water at a stated time. The consumer opens the outside gate and takes whatever head he can best use. The amount of water to be used is determined by crop-acreage, soil, etc. During irrigation he may either increase or decrease this head according to the way the ground is absorbing moisture. When the consumer is through irrigating, the zanjero takes another reading, leaves a shut-off notice including note of the amount of water used, and pulls the gear train and propeller for setting for another consumer.

To the best of my knowledge this type of service is not available nor required in any other city, but the demand for such a service here arises from the rather remarkable condition that probably does not exist elsewhere. Within our city limits, in the San Fernando Valley, we have large agricultural tracts ranging from 10 to 1000 acres, planted to oranges, lemons, walnuts, grapes, olives and alfalfa, or for quantity production of celery, lettuce, beans, tomatoes, melons, etc., and these crops are to be a great extent existent only because they have a dependable, regulated water supply.

The almost unbelievable rate of 1.75 cents and 3.8 cents per 100 cubic feet for irrigation water, when the domestic rate for this same water is 15.5 cents, is quite justifiable when it is explained that we have another angle other than the original plan for stimulation of agricultural activity at close range for the purpose of supplying necessary food products such as poultry, eggs, vegetables and fruits, to our population at a reasonable cost.

The San Fernando Valley, where these low irrigation rates are applicable, has for many years been recognized as an invaluable ground-water storage basin, by engineers and those intimately con-

nected with the water resources of our city. It was this feature that determined the location of the terminus of the 328-mile Owens River Aqueduct at the upper boundary of the San Fernando Valley.

It was believed and later on proved that bringing in this aqueduct supply and selling all water not needed for domestic consumption to the ranchers of the valley, would stimulate a generous use of this water; and the water so used would percolate through the porous alluvial soil into this underground basin and thus add to our underground supply. The size of the city makes it imperative that all available methods of water storage (both surface and underground) be utilized; and this percolating water is stored underground, making it available within the metropolitan area, thereby reducing the hazard of water shortage through an interruption along the aqueduct. As a final bit of information, it may interest you to know that engineering studies and tests have proven that approximately 30 per cent of the water used for irrigation is later recovered through our emergency pumping plant in the central portion of the valley, or, later on, through the lower diversion works from Griffith Park to the Elysian Park Narrows. This pumped water is then resold at the regular domestic rate of 15.5 cents per 100 cubic feet.

SPECIAL RATES

City parks and playgrounds, the main library grounds, golf courses and polo fields have a special rate of 5.9 cents per hundred cubic feet.

CUSTOMER RELATIONS

From this collection of facts and figures it can readily be seen that the business procedure in connection with the sale of such a quantity of water for these various types of service, is a never-ending study of what can be done and what must be done to secure economic security for our Water Bureau and still furnish the consumer with an adequate dependable supply of pure water at low cost.

We make every effort to familiarize our consumers with our problems, for it is only through a thorough knowledge of the accomplishments and aims of our Water Bureau that our citizens can test the efficiency of our organization and appreciate the problems we must meet and solve to the best interests of all concerned; for after all is said and done, the relationship between an organization and its customers is the governing factor in its success or failure.

The value of the human contact in business, as we all know, is one that cannot be over-estimated and it should be maintained in every way possible. The Department of Water and Power lost a certain measure of this valuable personal contact when it abolished house to house collection of bills; but in the interests of efficiency this loss was felt to be more than offset by the many advantages of the mailing system.

A water system assumes a tremendous responsibility to the community and to its customers; and we share, with the other progressive utilities of this association, the feeling that the responsibility of the utility does not end when the meter is installed.

This installation is the beginning of a business relationship which the organization hopes to enjoy over a period of many years. The customer has a right to expect us to deliver to him water—without interruption—at a minimum cost; and it is the business of our water sales division to do our part in fulfilling this obligation.

Discussion by Henry E. Nunn.[1] Mr. Erwin has outlined, in complete and thorough manner, the financing plan of the Los Angeles Water Sales Division. A proper review of this paper would entail much study of the rules and regulations of this department. Hence, this discussion will not cover all the many unique problems, which are peculiar to Los Angeles. Many of them are peculiar problems, the solution of which is to meet the situation in hand equitably regardless of some other city's method of meeting a more or less similar situation.

For instance the practice of reclaiming 30 per cent of the water sold in the San Fernando Valley, is most interesting though very few other cities have the opportunity of duplicating this practice.

The paper gives us an idea of the value of sound planning and complete records, in meeting so many varying problems as: eleven elevation zones, supplied by gravity; other zones demanding pumping stations; serving consumers outside the city; as well as giving service to irrigation consumers from the supply line.

It is our purpose to mention a few points to bring out a discussion of the practice in other cities. The system of service connection charges, at a flat rate for each, based on previous cost records, certainly eliminates extra work in individual investigations; deposits covering cost of the work; and the necessity of making refunds, or additional charges, for inexact estimates.

Another interesting feature is the practice, under certain conditions

[1] Superintendent of Water Works, Van Buren, Arkansas.

since January of this year, of waiving a service deposit where meters are of smaller size than 1-inch. This undoubtedly, is a saving in clerical work, recording the receipt, paying interest on the deposit, refunds, etc. Is this saving offset by extra turnoffs, which would then necessitate deposits after a few months, because of a lower credit rating?

A number of cities in our section find the greatest hazard among the consumers using the smaller services. Consumers having larger services usually have an established business and a credit rating.

Another interesting feature is the fact that different service deposits are charged for Intermittent Irrigation Service meters.

I agree with Mr. Erwin on the justice of a "ready to serve" charge. It costs more to be ready to serve the average domestic consumer, than it does actually to deliver the water he uses, after the connections are installed.

In Arkansas a number of plants have been built and extensions made by the formation of Improvement Districts. In these cases, the costs of the improvement are distributed over the property as assessed benefits. These assessed benefits being equal to the amount of bonds and interest. An improvement tax is levied to be collected annually until the bonds are paid. In many cases, the plant earnings have lowered the tax materially, but the property benefitted has paid for part of the improvement.

I note that Los Angeles follows the usual custom of fixing higher rates outside the city,—thus letting the individual outside the city who gets the benefits of the original outlay for plant and supply mains help pay for them in the form of a higher rate.

METER MAINTENANCE

By J. A. Mitchell

Many splendid articles relative to metering and meter maintenance have recently appeared in various water works publications. Almost without exception these discussions have assumed that an efficient meter department already exists and have dealt with unusual and often extremely technical cases.

The writer believes that a simple, elementary discussion of the value and methods of accurately measuring water would be of interest to the many operators who have not recognized the importance of complete and accurate registration.

In many cases the excessive loss of water is corrected by the detection and repair of leaks in services, hydrants, toilets and other fixtures. Often there is no waste, but is a naturally large consumption which should be, and is, subject to pro-rata collection after a meter is installed. In view of these actual figures it becomes evident that any plant which suffers from an extremely high per capita use would in all probability profit by a metering program. The expense, at least to a large measure, would be borne by the saving in production, purification, and distribution costs and in many cases aided by an increased revenue.

Whether in a mass metering program or a single new service installation an important item is the type and size to be used. "Standard Specifications," adopted by The American Water Works Association, serves as an excellent guide in this respect. The regular disc or displacement style is, of course, the ideal residential meter. So long as the requirements do not demand flows of high peak rates this meter is also satisfactory in large sizes. However, where a high peak rate is reached and sustained we have found in this style a tendency to wear and need replacement parts. For industrial consumers who use a large flow of water during a given period the current or velocity type

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A paper presented at the meeting of the Illinois Section at Decatur April, 1938. The author, J. A. Mitchell, is Meter Superintendent of the Illinois Public Service Co., Champaign, Illinois.

will prove satisfactory and not so susceptible to wear. However, it cannot be depended upon for consistent accuracy except where its comparatively large rated flow is maintained.

For users who cover a great range from a very high peak load to a small stream the compound type meter embodying both the current and displacement type is ideal. Almost all meter manufacturers offer a meter of this type which depends on an automatic valve, designed to open during the large flow allowing the current type to carry the load and close on a small flow forcing the water through the smaller displacement section. Thus, this style combines the durability of the current type and the accuracy of the disc type.

We have used the term "completely metered." Let us now consider when these services may be said to be completely metered. Only by accurately measuring the water delivered against that consumed can we hold the leakage or waste within the system to a reasonable limit. An interesting series of tests conducted at Hartford, Connecticut and reported in 1933 to the New England Water Works Association, indicated that in houses equipped with tank toilets 27 to 50 per cent of the total amount of water used was at rates of less than one gallon per minute and from 33 to 78 per cent was used at less than two gallons per minute. Obviously then it is vitally important that meter maintenance be carried to such an extent that accuracy is preserved well below the above mentioned one gallon per minute.

Relative to accuracy we find in Rule No. 8 of the Illinois Commerce Commission: "A water meter shall be tested by comparing the actual amount of water passing through it with the amount as indicated on the dial. A test shall consist of passing water through the meter at the three following rates:

(1) Approximately one-eighth flow.
(2) Approximately one-half flow.
(3) Full flow.

No meter shall be put in service or allowed to remain in service when it shows an error in registration of more than 4 per cent on either flows (1) or (2) or more than 2 per cent on flow (3). The average error shall not be greater than 2 per cent.

The utility may make such additional tests as it may deem necessary but in such a manner as not unreasonably to inconvenience the consumer.

Note: Upon application to the commission, exceptions to the above method of testing may be granted for meters above 2-inch size. The method of such testing must be approved by the commission."

This rule, of course, deals basically with allowable error of registration. The writer believes that additional tests on the $\frac{1}{16}$-inch and $\frac{1}{32}$-inch streams would prove valuable to the operator. The required $\frac{1}{8}$-inch stream, approximately three gallons per minute at average test pressures gives no assurance of the accurate, or even partial, registration of the important small flows.

While dealing with required accuracy it is well to consider that in many types of water there is a speeding up of new or repaired meters in actual service. This is due to deposits which, without friction, seal the clearances in the assembly and eliminate by-passing, as well as reduce the capacity of the measuring chamber. The presence and the average amount of this increase is largely a local condition and the necessary allowance for it must be based upon observation and experiment.

Our meter department values testing and maintenance so highly that each time a service is disconnected the meter is brought in for test and inspection. In addition to this a constant general test is carried on. While we, in most cases, complete our general tests more frequently than required by Rule No. 12 of the Illinois Commerce Commission, I believe that this rule would serve as an excellent schedule even to those outside its jurisdiction. Rule No. 12 reads as follows:

"No water meter shall be kept in service for a period longer than, nor for a registration greater than, that specified in the following table, without checking it for accuracy and readjusting it if found to be inaccurate beyond the limits mentioned in Rule 8.

Five-eighths-inch meter 10 years or 100,000 cubic feet; $\frac{3}{4}$-inch meter 8 years or 150,000 cubic feet; 1-inch meter 6 years or 300,000 cubic feet; all meters above 1 inch 4 years."

All $\frac{5}{8}$ to 2-inch disc meters are tested at various flows ranging from the full stream to 0.2 gallons per minute. Five streams are run on the $\frac{5}{8}$ to 1-inch inclusive and six streams on the $1\frac{1}{2}$-inch or over. It is extremely important that each meter be tested at various rates of flow as the curve when charted may show considerable variation. If the meter is in good condition the curve described may be materially higher on the intermediate streams than on the large flows. In discussing this with the personnel of other plants I find that it is

not commonly known nor taken into consideration. That the full flows fail to register as fully as the intermediate streams is probably due to loss of head and resultant pressure differences which allows water to be driven through the necessary clearances in the disc assembly, while on the intermediate streams the pressure is more equal and by-passing is reduced. On the other hand, if friction is present anywhere within the moving parts of the meter the curve may be steadily downward as less velocity is exerted to overcome the drag.

We consider the smaller sizes accurate only when 98 to 100 per cent accurate at 0.8 gallons per minute. At 0.2 gallons per minute they must run consistently though no absolute percentage is required. Time is saved by not attempting to arrive at a definite percentage on this stream, and repeated cross section tests have indicated that if the meter runs consistently a 90 per cent to 100 per cent registration is almost invariably assured. It is true that some obsolete makes and models cannot be made to operate efficiently on such small flows. Many of these even when new never professed the accuracy which modern methods of manufacture now give. Abandonment of these obsolete meters would preserve uniformity and very likely show an ultimate profit.

ROUTINE TESTING AND REPAIRS

These tests should be determined either by weight or by measure in a volumetric tank. Whether weight or volume is the unit of measure, allowance must be made for sufficient water to complete at least one revolution of the smallest indice on the meter tested.

Little accuracy could be obtained in an attempt to gear at one-tenth of one revolution for if the indice is not centered correctly the reading would not be accurate.

Where many meters are to be tested much time and labor can be saved with a multiple test rack allowing several meters to be tested at the same time. These are equipped with interchangeable fittings for all styles and sizes up to 2-inch meters. For leakage tests, a hand pressure pump may be installed at the inlet side of the rack. If no leaks are present at 140 pounds the meter will probably give no future trouble by leaking.

A well equipped and well lighted shop is a necessity for the rebuilding and maintenance of meters. Much good can no doubt be accomplished with a portable testing outfit but a uniform repair

would be impractical due to the difficulty of carrying repair parts, tools, and machinery. No shop can hope to repair efficiently without a complete line of parts for each make and style of meter to be repaired.

A reasonable number of every part should be kept in stock. Some of the major parts which will invariably be needed are: register gears, dial plates, bottom plates, bushings, lids and glasses; gear train control blocks, clamp nuts, packing nuts, gaskets and prepared packing; bottom caps or frost plates, gaskets, nuts, bolts and washers, disc chambers and discs. Consult a parts catalogue of the makes to be repaired and obtain a complete line of parts.

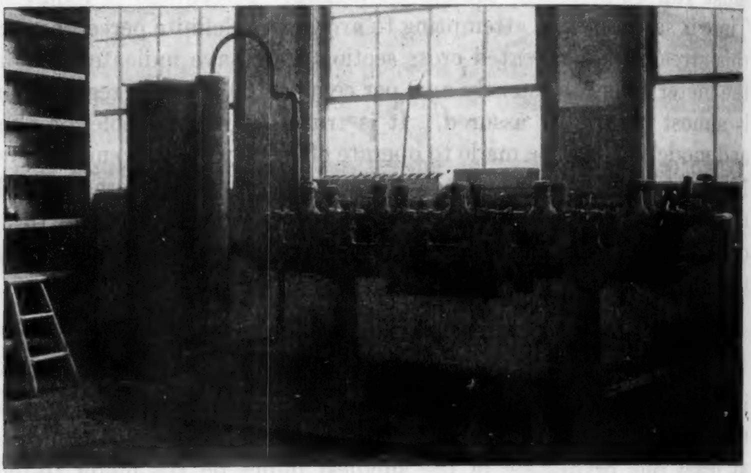


Fig. 1. Meter Test Bench—Hand Pressure Pump at Right

Particular attention should be given to the disc supply. Disc selection should be complete as to ball sizes for this is the means provided to compensate for wear in the ball socket of the disc chamber. Variation in the ball size alone will cause failure on the desired small flow tests. Once a complete line of parts is established it can be maintained at a reasonable cost.

An adequate surplus of all size meters is desirable, as occasionally some special part must be ordered from the warehouse or factory necessitating inactivity until the repair is completed.

Few special or expensive tools are necessary to a common sense repair program. Meter manufacturers supply special wrenches

designed for their own product, which may and should be obtained. A wood hammer is valuable in taking the meter apart as it does not batter or spring the casing. A complete set of reamers from $\frac{3}{16}$-inch downward is necessary for register and gear train repairs.

When a displacement meter fails, it is torn down and each moving part examined. Each separate gear in the gear train is checked for wear and to see that the teeth mesh correctly. If the teeth are not worn or bent a reamer will refit the bearings. The shaft of the gear which extends through the stuffing box should be checked for wear that might chew or bind when the packing is drawn into place. The

FIG. 2. OPEN AND CLOSED STORAGE SPACE—METER REPAIR SHOP

control block must be free but not worn enough to allow any whip or play.

Registers, both round and straight reading, must be given especial attention. In cases where consumption has been very low the upper indices have remained almost inactive. Often corrosion has set in to such an extent that the spur gears are almost destroyed. This is one of the most difficult defects to detect as the smaller indices and the test hand may be comparatively free while the larger is completely stopped. No meter should be put into service until the register has been checked for freedom and strength at every gear and indice. Discolored and illegible register dial plates may be quickly and inexpensively replaced.

The heart of a meter itself, the motive power, is in the disc chamber assembly. This should be as closely fit as possible with an absolute minimum of friction. Close attention should be given the disc which has failed, for evidences of hot water. Excessive polish or shine on the disc ball often indicates a swollen condition, usually due to hot water, which has created a binding tendency in the chamber. It will be found occasionally that even with a new disc of the proper size an adequate test will not be accomplished. This usually means that the disc chamber is sprung. If after repeated trials with varying disc sizes the small streams still fail to register, a new chamber should be installed. The use of acids for cleaning the chamber should be avoided wherever possible as this pits or etches the machined surfaces. Soap and water, or a fine abrasive in most cases will prove an adequate cleanser.

Scraping of discs, while not unpardonable, is not good practice. It will result in a rough spot which may clog and cause a premature drag or stream failure to register on low flow. Similarly, grinding in the disc to fit the chamber is not encouraged. While the meter may be made to run properly at the time tested, the grinding compound may penetrate the rubber disc and continue to grind after the meter is in actual service.

If a maximum of service is to be expected from the meter which has failed, all worn parts should be renewed, for it should be borne in mind that perhaps several years hard service will be added to the wear already present. If one weak unit is allowed to remain it may result in an early failure and cause an undue loss of revenue.

COMPOUND METERS

We observe an established routine for testing our compound meters. This consists of an annual overhaul, consisting of cleaning and testing during the summer months. In between these tests, or at the six months interval, the meter is cleaned and checked. In each case particular attention is given to the compound valve and compound valve gasket which, in opening and closing, is subjected to considerable wear. This periodic cleaning has an especial significance, as there is a prevalent tendency in the current types to speed up with use, due to the deposit which forms in the vanes of the motive wheel. Observing this natural speeding up of the current types we invariably gear below the legal rate, allowing for a reasonable increase in registration during the six months which will elapse before further

attention is given to the meter. Tests before repairs have repeatedly proven that in this manner we maintain a full but legal average registration.

For this test a portable testing assembly is used. This assembly consists of two previously tested displacement meters, a 2-inch for the larger streams and a $\frac{3}{4}$-inch for the small flows. The two are made selective by the installation of valves by which either may be closed. A means of inserting various orifices and a quick closing valve completes the assembly.

FIG. 3. COMPOUND METER TEST ASSEMBLY

Provision for these periodic tests is made at each permanent installation. A by-pass (including a locked gate valve) is built around each large meter to allow uninterrupted service while tests are being run. Valves must be installed at each end of the permanent meter, at the meter side of the inlet and outlet of the by-pass. At a point which allows the water to complete its circuit through the permanent meter, a two inch riser is installed. This serves as the test plug. A two and one-half inch hose is run from this riser to the test meter.

By changing the orifice size, which is done at the outlet side of the test meter, both sections of the compound may be geared to a pre-

determined point. After this has been satisfactorily accomplished, several intermediate streams are run to find the changeover point, or the flow at which the current type ceases to function, putting the load on the displacement section. A natural falling off in registration may be expected here, as the valve will not be stationary in either an open or closed position. Thus the current section will run spasmodically since the rate of flow is not great enough to hold the valve open, while the valve is not closed tightly enough to force the water into the disc section. At the rate of flow where this changeover takes place, a registration of eighty-five per cent or over is acceptable.

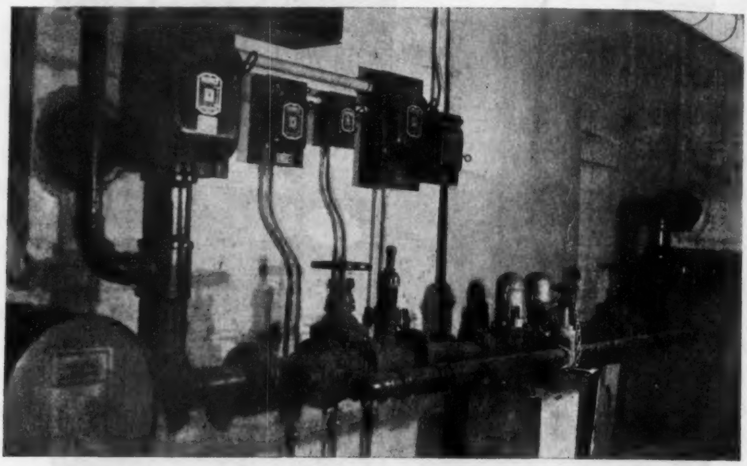


FIG. 4. COMPOUND METER INSTALLATION. NOTE BY-PASS WITH LOCKED VALVE

Independent of the office records, the meter department keeps a record of each meter brought in. If there is any question of the meter reading, its condition, or its accuracy upon removal, there is a complete record available. Permanent records are kept of the test before and after repair on the small sizes which have been through the shop as well as on the larger sizes where the portable testing assembly was used.

There is no great difficulty to be anticipated in establishing an efficient system of maintenance. This work may be trusted to a thorough, normally intelligent workman with the assurance that he will become quite expert. Testing equipment companies furnish splendid literature and plans to anyone interested.

To blindly trust that a meter is in satisfactory condition because the hands occasionally move, is to give, a five to fifty per cent reduction to many customers and an illegally high rate to others. This is not quite just to the consumers, but the greatest injustice is to those who operate the water system and try to show a reasonable profit at the close of the year.

UP-TO-DATE METHODS OF METER TESTING

By John L. Ford and Richard V. Ford

There is not much difference between up-to-date meter testing and out-of-date meter testing. David Harum said "there's mighty little difference between various folks but what difference there is, is mighty important." The same saying applies to methods of testing water meters.

The testing of water meters alone will not increase the income of any water utility. Meter testing must be correlated with intelligent and careful meter repairing so that full advantage can be taken of information learned in the testing. After all, it is accurate registration in service that is the goal of all metering and all of our testing simply tells us what we can and should do to approach that end. The principle of all meter testing is the same,—to check the registration of the meter against the known amount of water that has caused the registration. Scales and tanks for measuring water used in testing have been developed and there are several machines on the market for holding meters during test,—these have been in use for many years.

In his book published fifteen years ago, "Meter Rates for Water Works," Allen Hazen said, "It is obvious that testing meters, especially domestic water meters, at low rates of flow goes to the heart of the under-registration problem. Testing meters at ordinary rates has been brought to a high state of perfection where little can be suggested to improve it, but testing meters at low rates has been neglected." I would like to correct one inferred inaccuracy of his statement by adding that low rates *are* ordinary rates, and that low-rate testing is therefore more important than high-rate testing. Remember that nearly all faucet and toilet leaks, and such uses as water cooled refrigerators, fish ponds, etc., are at rates of less than one gallon per minute *and* that they endure 24 hours per day.

A paper presented before the Finance and Accounting Division at the New Orleans Convention, April, 1938. The authors are John L. Ford, Sales Manager, and Richard V. Ford, Vice President, Ford Meter Box Co., Wabash, Indiana.

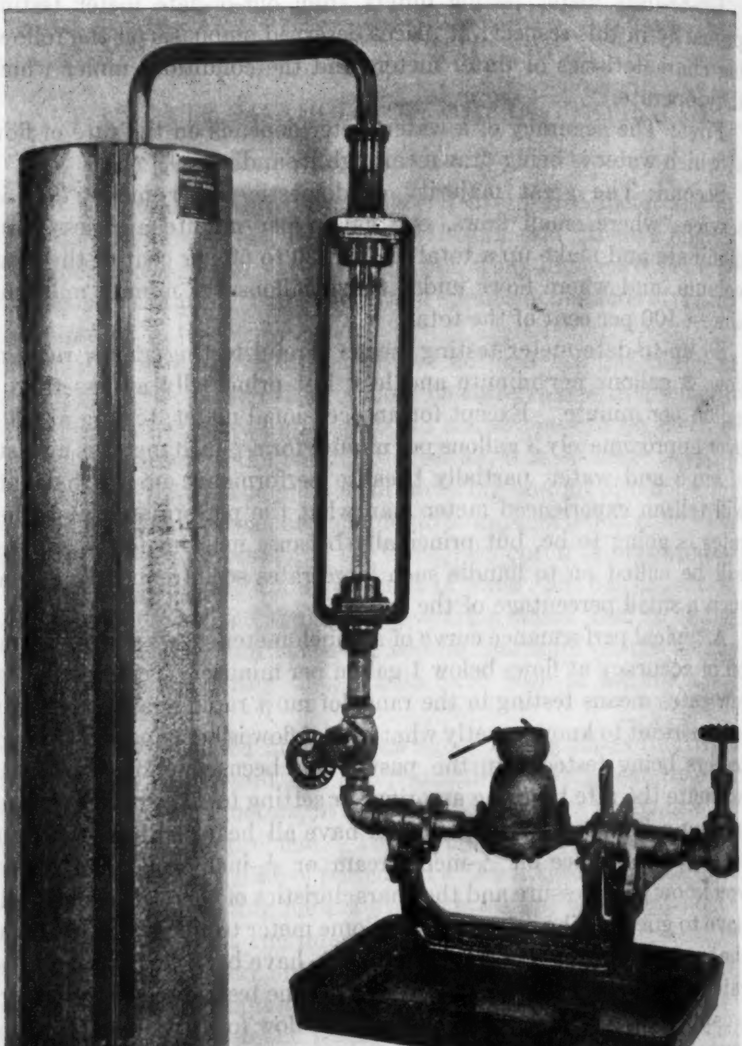
Up-to-date meter testing differs from out-of-date meter testing primarily in this respect: It places deserved emphasis on the following characteristics of water meters and the conditions under which they operate.

First: The accuracy of a water meter depends on the rate of flow at which water is being drawn through it, and

Second: The great majority of domestic water meters are in services where small flows, one gallon per minute and less, predominate and make up a total of from 30 to 50 per cent of the total volume, and where flows under three gallons per minute make up almost 100 per cent of the total.

So up-to-date meter testing means careful testing at low rates of flow, 3 gallons per minute and less, but principally at less than 1 gallon per minute. Except for an occasional meter, testing at rates over approximately 3 gallons per minute for a $\frac{5}{8}$-inch meter is a waste of time and water, partially because performance up to that rate will tell an experienced meter man what the performance at higher rates is going to be, but principally because most meters in service will be called on to handle such large rates so infrequently and as such a small percentage of the total.

A typical performance curve of a $\frac{5}{8}$-inch meter shows a rapid falling off of accuracy at flows below 1 gallon per minute. Testing at these low rates means testing in the range of most rapid change so that it is important to know exactly what rate of flow is being passed through meters being tested. In the past it has been common practice to estimate the rate by using an orifice or setting to some orifice equivalent on a flow control valve. You have all heard statements about meter performance on $\frac{1}{16}$-inch stream or $\frac{1}{32}$-inch stream but unless you know the pressure and the characteristics of the orifice you really have to guess at the rate of flow. Some meter testing shops, realizing the inaccuracies of orifice measurement, have been setting small test rates by funnels, running the water from the testing machine through a calibrated funnel which shows rates of flow for certain levels in the funnel. This is fairly accurate but not entirely satisfactory because it is difficult to adjust the flow to the desired rate due to the necessary wait for the water to reach the level where input equals discharge. Other progressive meter shops have rigged up orifices with U tubes containing mercury or carbon tetrachloride which show rates of flow with considerable accuracy. However, to cover the entire range of flows used in meter testing, several such devices are necessary, which adds to the complication.



The Testerate Indicator in Operation

Our company has been working on the development of a special Rotameter, designed especially for water meter testing, which will show directly and instantly any flow from $\frac{1}{20}$ gallon per minute to 35 gallons per minute with extreme accuracy, particularly on flows up to 4 gallons per minute. This Testerate Indicator consists of a special double-taper glass Rotameter tube within which a special rotor of stainless steel is supported by the rising flow of water and assumes a position indicative of the rate and can be read directly from the markings on the glass tube. The many advantages of this device are apparent. As yet we have had insufficient opportunity to experiment with this Testerate Indicator to speak with authority on the possibilities it may open up. The remarks from here on may be considered speculative and offered as a challenge to those concerned with the performance of water meters. The ability to read accurately and instantly any rate from zero up to any desired figure, or the ability to set a rate of flow at some exact figure opens up desired possibilities in connection with meter performance.

Any disc water meter will pass extremely small flows without registering them. As the flow is increased there comes a rate at which the disc begins to move with the water and the meter starts to register. This may be called the "breakaway point" and is a more significant figure than the actual accuracy at any certain low flow. As soon as the meter starts, the registration jumps from zero to a good percentage, generally well over 50 per cent; the performance curve is almost vertical at the breakaway point. Amplifying the motion of the test hand mechanically, optically, or by a light beam makes possible the determination of the breakaway flow or starting point with reasonable accuracy, the rate of flow being read from the flow indicator. The ability to set a given rate of flow quickly and accurately makes possible a different kind of meter testing, which may be called chronological testing in that the factor of time is involved. This may be illustrated by a simple example. If exactly one gallon per minute is passed through a meter and it registers $\frac{95}{100}$ of a gallon in a minute, then the meter is 95 per cent accurate or 5 per cent slow at that rate. There are several possibilities in adapting this principle, which may be done electrically, optically or mechanically.

One possibility would be to clamp on a meter dial a small device which would make electrical contact with the test hand at a number of positions in its revolution. Then, with some definite and accurate

rate of flow passing through the meter the electrical impulses from the test hand could be used to mark a moving graph paper and the spacing of the marks would indicate meter accuracy. This arrangement might be used to advantage in series testing of several meters.

An electric clock could be started and stopped by electrical impulses. The dial could be marked in percentages fast and slow so that the position of the clock hand when it stops would indicate the accuracy of the meter. A rotating indicator, capable of being run at speeds corresponding to those of a test hand at various rates of flow, could be placed above the test hand of meter being tested. Then the flow through the meter could be adjusted to keep the meter test hand in pace with the timing hand, and the accuracy read direct from a percentage strip alongside the flow indicator. This would not be quite as accurate as volumetric testing but it would save much time on slow flows and would be sufficiently accurate for all practical purposes.

Such time testing would require an exact and steady test flow and might necessitate the use of a constant-level elevated tank for supply if the pressure were not steady enough. On the other hand, there would be a saving in draining test tanks, balancing scales, etc. It might not be necessary to do much volumetric testing except as an occasional check on a meter or on the Testerate Indicator.

This paper has not given many definite instructions on current practice in meter testing; this has been covered several times in the past. The importance of testing at low rates and of *knowing—not guessing,* just what those low rates are has been pointed out. A device, new to water meter testing, which indicates rates of flow directly and accurately and which permits setting a rate quickly to any desired figure has been described. Also, a little speculation has been done on the possibilities of meter inspection and testing which this rate-of-flow indicator may open up. Maybe some of these ideas will materialize into useful applications as we have more time to experiment and develop. At least the speculation must come first.

Discussion by C. M. Roos.[1] In this splendid paper some interesting, thought provoking and challenging ideas are presented which are quite original and which represent a departure from the usual conventional practices in meter testing.

This paper includes pertinent points of special interest which are

[1]Manager, The Cairo Water Co., Cairo, Illinois.

worthy of careful thought and consideration, some of which are as follows:

1. Small flows of under 1 to 3 gallons per minute constitute a larger percentage of the total consumption of water by the average domestic consumer than is usually realized.

2. The falling off of accuracy of the ordinary $\frac{5}{8}$-inch meter with flows less than 1 gallon per minute is quite rapid.

3. The determination of the accuracy of a meter when registering flows of less than 1 gallon per minute is not ascertainable conveniently or speedily by methods now in use in the average meter testing shop.

4. Maintaining mechanical precision in a meter when operating at small flows is important, but it is equally important to have such precision set and calibrated to measure accurately the quantity of water passing through the meter.

5. The ingenious methods of measuring small flows accurately and quickly, as described or suggested, open up possibilities in this field of water works operation which should prove to be of unusual interest, and they certainly warrant consideration and attention.

A cash register which is inaccurate in recording small denominations would be more objectionable in a dime store than in a wholesale business. A water meter is the water works cash register. A large percentage of the consumption of the average water utility is in the dime store classification.

Niagara Falls with its tremendous volume of water has cut away the hard limestone rocks for a distance of 7 miles to a depth of the great gorge. However the "constant drop (drop by drop) of water will likewise wear away the hardest stone," as is demonstrated by the changing of the topography of the surface of the entire earth through the ages. Small constant flows of water make up staggering aggregates.

Modern precision scales which are calibrated in fractions of an ounce, as used in grocery stores, as compared to the old type of scales, are sometimes the reason for the difference between solvency and insolvency of the grocer. The multiplication table is as inflexible as the "laws of the Medes and Persians."

Accuracy in watches is measured by seconds. If the seconds are accurate the hours cannot be otherwise.

Bankers use day tables rather than monthly schedules in computing interest on loans for obvious reasons, and sometimes much to the confusion of the borrower who tries to compute the interest himself.

An extra day's interest on a small loan means little, but in the aggregate the amount is large in the average bank.

Some interesting articles have appeared recently in water works literature on the subject of meter maintenance and testing. One large water utility reports that it limits its tests for very small flows to determining the mechanical operation of the meter. One large operator reports his meter shop so well equipped that some consideration has been given to manufacturing meters for his own use. Like the construction of almost anything from watches to houses, precision and quality of meters involve more than the use of a given quantity of materials and a known number of man hours of labor. Quality and composition of materials, skill, design, experience, tradition, careful analyses of material, etc., all should enter into the construction of anything worth while. The same materials and man hours of labor used in the manufacture of two watches in different factories may not produce the same quality of watch. Two dwellings may be constructed from the same quality of materials, representing the same cost and the same number of man hours of labor, and still be much different as to value, appearance and utility. The structure designed by a competent architect usually has a much better value and appearance than the one in which brick, mortar and labor only were considered in its construction. A given quantity of paint in the hands of an artist may produce a masterpiece as compared to the results of the use of the same materials by one not skilled in the art of using paint.

The Messrs. Ford have given us a new slide rule for computing the performance of a water meter, which is a water utility's cash register, and in describing it in this paper they have made a creditable contribution to the literature of the water works profession.

APPLICATIONS OF CARBONACEOUS ZEOLITES TO WATER SOFTENING

By S. B. Applebaum

Research, the handmaiden to industry, has given us carbonaceous zeolite as the latest member to be added to the group of zeolites which have been in service in various forms for over 25 years. The term "zeolite" was originally a mineralogical name for a specific family of substances. But as used in the water conditioning field, it has been broadened to mean any hard granular material (through which the water percolates) which reacts chemically with the water, without going into solution, so that cations in the water, such as Ca, Mg, Fe, etc. are exchanged for cations in the zeolite, such as Na, etc. and which may be regenerated by the reverse reaction in repeated cycles. The well-known general reaction of sodium zeolite softening is (Let Z = Zeolite):

$$1) \quad \left.\begin{matrix} Ca \\ Mg \end{matrix}\right\} \text{salts} + Na_2Z = \left.\begin{matrix} Ca \\ Mg \end{matrix}\right\} Z + Na_2 \text{ salts}$$

The regeneration reaction is:

$$2) \quad \left.\begin{matrix} Ca \\ Mg \end{matrix}\right\} Z + 2\,NaCl = Na_2Z + \left.\begin{matrix} Ca \\ Mg \end{matrix}\right\} Cl_2$$

Until carbonaceous zeolites appeared, the zeolites were used as sodium zeolite only and the cations were all basic, so that the term "base exchange" material was often used instead of sodium zeolite. Table 1 lists these older sodium zeolites and briefly gives their silica content, weight per cu. ft., capacities and characteristics. From this table it is to be noted that they all had in common, a large amount of SiO_2 in their composition. They may therefore be classified in general as the Siliceous Zeolites.

Carbonaceous zeolites, as the name implies, consist mainly of carbon. The carbonaceous zeolite now in commercial application

A paper presented at the New Orleans convention, April 26, 1938, by S. B. Applebaum, Vice-President, The Permutit Co., New York.

(Zeo-Karb) is manufactured from a carbonaceous material such as coal, by a special treatment with chemicals, such as sulfuric acid or sulfur trioxide (SO_3), etc., after which it is washed, stabilized and screened. The resultant product is black, hard and granular. Its silica content is negligible, being no greater than that contained in the original coal. It is therefore non-siliceous and the term "carbonaceous" is correctly applied to it.

TABLE 1

Siliceous zeolites

POPULAR NAME	WEIGHT PER CU. FT., LBS.	EXCHANGE CAPACITY* GRAINS OF $CaCO_3$ PER CU. FT. OF ZEOLITE	PER CENT SiO_2	REMARKS
Fused synthetic	50	4000–6000	50	First zeolite made. No longer used
Precipitated synthetic (Decalso)	50	7500–10,000	60	Sensitive to aggressive waters. Suitable for clear hard water, over 10 gr./gal. hardness, where pH not below 6.8
Glauconite or greensand (Zeo-Dur)	90	2400–3000	45	More resistant to aggressive waters
High-capacity greensand (Super-Zeo-Dur)	80	4000–5500	45	
Clay		5000–7000	50	Sensitivity similar to precipitated synthetic

* The range of capacity given corresponds to the usual range of amounts of salt used in regeneration (0.35 to 0.5 lb. salt per 1,000 grains of hardness removed). These are the ratings used in industrial practice. Laboratory softener tube tests give higher capacities.

When regenerated with sodium chloride (NaCl), carbonaceous zeolite operates as a sodium zeolite (Zeo-Karb Na) by base exchange as do the other zeolites given in table 1. Its capacity is 5,000–8,000 grains of $CaCO_3$ removed per cubic foot, depending on the amount of salt used for regeneration. It is completely resistant to aggressive, low pH waters and is satisfactorily used to soften either hard or relatively soft waters. The granule sizes are large and it therefore

can handle high flow rates (6 to 8 g.p.m./sq. ft.) with very low loss of head.

Due to its complete resistance to acids, it can be regenerated with acids, such as sulfuric acid, to form hydrogen zeolite (Zeo-Karb H). This hydrogen ion in the zeolite is exchangeable for the cations Ca, Mg or Na in the water per the following general reactions (Let Z = Zeolite):

$$3)\quad \left.\begin{matrix}Ca\\ Mg\\ Na_2\end{matrix}\right\} (HCO_3)_2 + H_2Z = 2\,H_2CO_3 + \left.\begin{matrix}Ca\\ Mg\\ Na_2\end{matrix}\right\} Z$$

$$4)\quad \left.\begin{matrix}Ca\\ Mg\\ Na_2\end{matrix}\right\} SO_4 + H_2Z = H_2SO_4 + \left.\begin{matrix}Ca\\ Mg\\ Na_2\end{matrix}\right\} Z$$

$$5)\quad \left.\begin{matrix}Ca\\ Mg\\ Na_2\end{matrix}\right\} Cl_2 + H_2Z = 2\,HCl + \left.\begin{matrix}Ca\\ Mg\\ Na_2\end{matrix}\right\} Z$$

The regeneration reaction is:

$$6)\quad \left.\begin{matrix}Ca\\ Mg\\ Na_2\end{matrix}\right\} Z + H_2SO_4 = H_2Z + \left.\begin{matrix}Ca\\ Mg\\ Na_2\end{matrix}\right\} SO_4$$

When Zeo-Karb is used as a hydrogen zeolite, its capacity is 8,000 to 9,000 grains of cation (the sum of Ca, Mg, & Na, all expressed as $CaCO_3$) per cubic foot of Zeo-Karb when regenerated with 2.25 to 3.00 lb. acid (66° Be H_2SO_4) per cubic foot of Zeo-Karb. The amount of acid required varies to some extent with the composition of the water.

The concept of a hydrogen zeolite is not new. But hitherto no material was developed that could stand up successfully in that kind of service. The advent of the new carbonaceous zeolites, used in the hydrogen cycle, therefore ushers in a new chapter in zeolite water softening and presents the opportunity for a number of interesting applications in the water conditioning field. Siliceous zeolites will still find their place in water conditioning and it is the purpose of this paper merely to indicate the field of application for the carbonaceous material, where the properties of the latter are of particular significance.

Since the hydrogen in the hydrogen zeolite is not a base, it is improper to speak of the reactions (3) to (5) as "base exchange" reactions. Therefore, it would be clearer from now on, instead of "base exchange" to use the general term "cation exchange" since Ca, Mg, Fe, Na and H are all cations. The broad field of "cation exchangers" can then be subdivided into two groups:

a) *Base Exchangers*—Those which exchange basic cations, e.g., The Na ion of the material for the Ca and Mg ions in the water, and the reverse when regenerated with an Na salt like NaCl.

b) *Hydrogen Exchangers*—Those which exchange the H ion of the material for the Ca, Mg, and Na ions in the water, and the reverse when regenerated with an acid like H_2SO_4.

APPLICATION OF CARBONACEOUS BASE EXCHANGERS

In general, this material has found application for water softening in the following cases:

1) *Waters of low pH value (under 6.5)*, where it is desired to soften such waters at these low pH values.

2) *Waters high in iron.* Iron in ferrous form is removable by cation exchange. However, precautions must be used to avoid aerating the water before entering the zeolite, so as to keep the iron in ferrous form. Otherwise some ferric iron may deposit on the zeolite grains. Such ferric iron may be dissolved from the zeolite by application of acid. However, the older types of zeolite were subject to some attack by this acid. Zeo-Karb Na resists the attack of the acid and is therefore more applicable for the softening of high iron-bearing waters because if ferric iron deposits take place, an occasional wash with dilute acid solution will restore the Zeo-Karb grains to their original iron-free condition without any damage to them.

3) *Limited space for softeners.* Due to the large granule size of Zeo-Karb Na, high flow rates of 6 to 8 g.p.m./sq. ft. of softener area may be employed with losses of pressure of 5 to 10 lb. per sq. in. Where space is limited, smaller Zeo-Karb units find application instead of the larger, older zeolite softeners.

4) *Waters low in SiO_2.* If the SiO_2 content of the raw water is very low, 3 to 5 p.p.m., about 1 to 3 p.p.m. of SiO_2 will be dissolved from the siliceous zeolites, depending upon the raw water composition. The silica pickup is greater from the synthetic, precipitated type than from glauconite. Such waters will not pick up any silica from Zeo-Karb. This is particularly applicable in the power plant for boiler feed.

5) *Softening after silica removal.* Where the silica in the raw water is high, a silica removal plant may be installed to reduce the silica in the raw water. Case histories #1 and #2, described below, are representative of this class of treatment.

When the silica is reduced by suitable treatment, the effluent of the silica removal plant will be low in silica and would tend to pick up silica from siliceous zeolites. Zeo-Karb Na makes it possible to remove completely the residual hardness in low silica waters by the simple base exchange process without any danger of silica pickup.

As an alternate to Zeo-Karb Na, hot phosphate treatment may be used for the removal of hardness after silica removal treatment, provided the hardness is fairly low. The cost of phosphate for this purpose would be too high as compared with the cost of salt to regenerate Zeo-Karb, if the hardness is appreciable, as case history #1 indicates.

This boiler user has 3–900 lb. per sq. in. pressure Riley-Badenhausen boilers, each capable of evaporating 125,000 pounds per hour and the makeup is 85 to 100 per cent. In 1936 a 250,000 pound per hour water treatment plant was installed, consisting of Ferrisul-caustic soda cold process treatment for silica removal, followed by a hot tri-sodium phosphate-caustic soda treatment for hardness removal. At that time Zeo-Karb Na was not available in the quantities required for this plant.

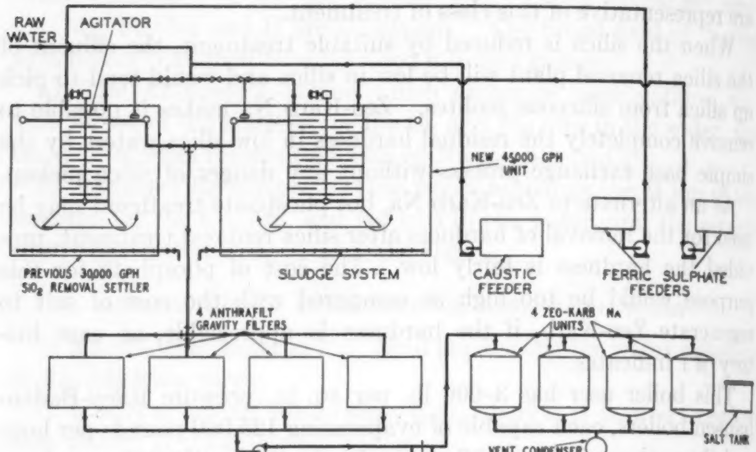
The silica removal plant was installed because silica deposits were feared in the boilers and turbines, due to the fact that at times there is a high amount of silica present in the raw water. Hot process treatment ordinarily does not reduce silica sufficiently and in this case, reduced it to a negligible extent. The silica removal plant reduced the silica from 9 p.p.m. down to 3.5 p.p.m.

The results of operation have been fairly satisfactory, except for caustic turbine deposits. These turbine deposits caused a drop in capacity of about 500 kw in two weeks. To help reduce these turbine deposits, it was decided to increase the sulfate-carbonate ratio to about 4.4:1.

Recently the boiler plant load increased to a peak of 375,000 pounds per hour and therefore additional water treatment equipment was required.

The extension which is just being made includes an additional silica removal installation of the same Ferrisul-caustic soda type as described above. However, the hardness removal, instead of being accomplished by hot phosphate, will be accomplished by Zeo-

Karb Na. A slight amount of H_2SO_4 will be added to the influent of the Zeo-Karb to reduce the pH value from 9 to 7.5 to prevent after-



CASE #1
SILICA REMOVAL AND ZEO-KARB NA WATER SOFTENERS
FIGURE #1
C-2677

reactions from coating the Zeo-Karb. Some phosphate will be added to the Zeo-Karb effluent to built up a PO_4 concentration in the boilers.

TABLE 2

Operating results—case 1

Caustic Ferrisul followed by hot phosphate compared with Caustic Ferrisul followed by Zeo-Karb Na

(17.1 p.p.m. = 1 grain per U. S. Gal. 120 p.p.m. = 1 lb./1000 gals. = 7 grs./gal.)

CHEMICAL EXPRESSION	SYMBOL	IN TERMS OF	(1) RAW	(2) (1) AFTER CAUSTIC FERRISUL	(3) (2) AFTER HOT CAUSTIC PHOSPHATE AND DE-AERATION	(4) (2) AFTER ACID ZEO-KARB Na PHOSPHATE AND DEAERATION
Total hardness............	TH	$CaCO_3$	30	22	0	0
Calcium....................	CaH	$CaCO_3$	26	18	0	0
Magnesium.................	MgH	$CaCO_3$	4	4	0	0
xAlk to M.O................	Alk A	$CaCO_3$	32	34	34	26
Basicity to Pht.............	Alk B	$CaCO_3$	6	8	17	0
Sodium Alk..................	Alk Na	Na_2CO_3	2	13	36	28
Free CO_2....................	CO_2	CO_2	0	0	0	0
xChlorides....................		NaCl	3	3	3	3
xSulfates......................		Na_2SO_4	3	124	124	135
Total solids (calculated by adding items marked x).	TS		38	161	161	164
Sulfate : carbonate ratio...		$\frac{Na_2SO_4}{Na_2CO_3}$		3.44	3.44	4.43
pH value.........................					9.5	8.0
Silica as.........................		SiO_2	9	3.5	3.5	3.5

Approximate chemical costs

	LB./1,000,000 LB. OR P.P.M.	COST, CENTS/LB.	COST/1,000,000 LB., DOLLARS
Silica removal:			
Caustic soda............................	51	2.17	1.11
Ferrisul..................................	115	2.20	2.53
			3.64
Hot phosphate:			
Caustic soda............................	2	2.17	0.11
$Na_3PO_4 \cdot H_2O$..........................	40	5.0	2.0
Sodium sulfite..........................	2	5.0	0.10
			2.21

TABLE 2—*Concluded*

Total cost of silica removal by hot phosphate = \$5.85

	LB./1,000,000 LB. OR P.P.M.	COST, CENTS/LB.	COST/1,000,000 LB., DOLLARS
Zeo-Karb Na:			
Sulfuric acid	8	0.6	0.05
Salt	63	0.273	0.17
Sodium sulfite	2	5.0	0.10
Na_2HPO_4	9	5.7	0.51
			0.83

Total cost of silica removal by Zeo-Karb Na = \$4.47

Saving in favor of Zeo-Karb Na/1,000,000 lb. = \$1.38.
6,000,000 lb./day × \$1.38 = \$8.30/day = \$3030/yr.

The Zeo-Karb Na treatment had the following advantages over the hot phosphate:

a) Higher sulfate-carbonate ratio to reduce turbine deposits.

b) Lower pH value in the feedwater, which is of importance because they are going to install a high pressure heater and they feared that hot phosphate treatment, operating at high pH values, would cause phosphate deposits in this heater. This was the experience of a Rochester utility company which operated with hot phosphate treatment. As a consequence, the latter concern installed an acid feed to reduce the pH value of the hot phosphate treated water from 9.5 down to 8.5 to reduce phosphate deposits in the feedwater heater and economizer.

c) Incidentally, these improvements in the quality of the effluent will be accomplished at a saving of considerable operating cost and with a lower initial investment, when considering the cost of installing the second hot process plant, steam piping and filters, and the cost of the space required for the hot process plant as compared with the Zeo-Karb installation.

Table 2 sets forth the chemical results at various stages of treatment and also the approximate chemical costs. Fig. 1 is the flow diagram and arrangement of the complete plant, showing that the hot phosphate equipment will be kept in reserve.

Case #2 illustrates the use of Zeo-Karb Na in a Southern Public Utility. In 1929 this boiler user installed 4-1,400 HP boilers equipped with steel tube economizers and operating at a normal gauge pressure of 650 pounds, maximum 705 pounds, makeup 80 to 90

per cent. At the same time a water treating plant was installed, having a capacity of 1,000,000 pounds per hour. Mississippi River water is the source of supply and originally the plant consisted of two steel presedimentation tanks to remove the heavy suspended matter from the river water in the first stage treatment, followed by six intermittent reaction tanks, in which lime and some soda ash was to be added to presoften the water in the second stage treatment. The settled water then passed through eight wood gravity filters into a concrete clearwell. Sulfuric acid was added between the filters and the clearwell in order to reduce the pH value down to 6.5 to 7.5. The acid-treated water was then pumped from the clear-

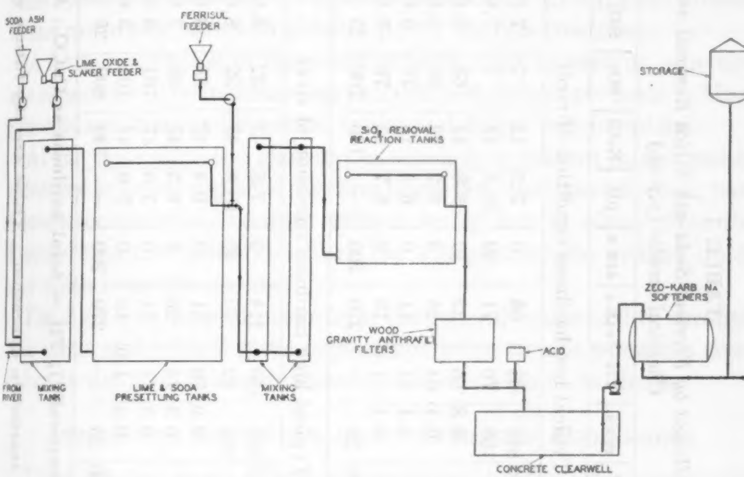


FIGURE 2
LIME & SODA ASH SOFTENING + SiO_2 REMOVAL + ZEO-KARB NA
CASE #2

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well through five horizontal pressure zeolite softeners of the glauconite type into elevated storage. The water is passed into a deaerating heater, after which a little sodium sulfite is added to complete the deaeration. Finally some phosphate is added directly into the boilers to set up a secondary line of defense against hardness in the boilers.

This plant was extended in 1931 to handle a capacity of 1,500,000 pounds per hour by adding one more reaction tank, two more filters and two more softeners.

In the operation of this plant during the last eight years, it was found beneficial to add the lime and soda ash into the presedimenta-

TABLE 3

Case 2. Lime-Soda Pre-Softening followed by Ferrisul-Soda ash Silica Removal and Zeo-Karb Na final softening
Chemical results (p.p.m.)

SAMPLING POINT	TS*	TURB.	TH	ALK A	ALK B	pH	NaCl	SO_4	SiO_2	PO_4	DOSAGE	P.P.M.
Typical low hardness condition of river												
1) River	100	840	86	66	0	7.5	13	7	7.0	0	$Ca(OH)_2$	85 } 1st stage
2) After lime and soda	—	168	70	71	49	10.3	13	7	7.0	0	Na_2CO_3	25 } 1st stage
3) After Ferrisul	—	0.8	66	32	10	9.3	13	63	3.0	0	Ferrisul	75 } 2nd stage†
4) After filters	—	0.1	64	25	8	9.2	13	63	3.0	0	Na_2CO_3	35 } 2nd stage†
5) After acid	—	0.1	64	11	0	6.5	13	76	3.0	0		
6) After Zeo-Karb Na	—	0.1	1.0	13	0	6.7	13	76	3.0	0		
7) Boiler saline	1500	25	—	270	200	—	146	700	25	40		
Typical high hardness condition of river												
1) River	213	625	150	114	0	7.6	47	32	8.0	0	$Ca(OH)_2$	125 } 1st stage
2) After lime and soda	—	162	82	70	49	10.3	47	32	8.0	0	Na_2CO_3	25 } 1st stage
3) After Ferrisul	—	2.0	76	31	10	9.4	47	88	3.0	0	Ferrisul	75 } 2nd stage†
4) After filters	—	0.3	74	25	8	9.3	47	88	3.0	0	Na_2CO_3	35 } 2nd stage†
5) After acid	—	0.3	74	11	0	7.0	47	101	3.0	0		
6) After Zeo-Karb Na	—	0.3	1.0	13	0	7.0	47	101	3.0	0		
7) Boiler saline	1800	25	—	270	200	—	340	800	25	40		

* TS = total solids (determined gravimetrically); TH = total hardness as $CaCO_3$; Alk A = methyl alkalinity as $CaCO_3$; Alk B = phenol alkalinity as $CaCO_3$.

† This Ferrisul treatment has not yet started in operation. These are the future anticipated results.

tion tanks, so that mud and precipitates of calcium carbonate and magnesium hydrate can be settled out simultaneously in these tanks. The reaction tanks then finished the treatment.

The silica in the raw water was not reduced by this treatment and it was found that a very thin analcite scale formed on some of the tubes in these boilers, especially where the rate of water circulation in these tubes was not as great as the rate of steam formed from these tubes. The scale in these particular tubes had to be removed at intervals of several months. It was therefore decided to change the method of treatment so as to add Ferrisul and soda ash into the reaction tanks to reduce the silica as the second stage treatment. It was found possible to reduce the silica from about 7 to 8 p.p.m. present in the raw water, down to about 3 p.p.m. by this treatment.

A further extension in this plant is being made at present, whereby the capacity will be increased up to 2,000,000 pounds per hour. More presedimentation and reaction tanks and filters will be added.

At the same time the glauconite, which is at present in the zeolite softeners is being replaced by Zeo-Karb Na, the non-siliceous, carbonaceous material, because with a water low in silica after the Ferrisul treatment, the Zeo-Karb Na will prevent the picking up of any silica from the zeolite.

Fig. 2 gives in diagrammatic form the general course of flow through this plant and table 3 gives typical operating results when the river is low in hardness and also when the river is high in hardness.

APPLICATION OF CARBONACEOUS HYDROGEN EXCHANGERS

There are two novel effects accomplished by the hydrogen zeolite reaction (3) previously given:

1) *Removal of sodium bicarbonate.* Hydrogen zeolite, according to this reaction, converts sodium bicarbonate into carbonic acid. This in turn can be removed from the water either by a cold degasifier or by a heater. Thus, sodium bicarbonate is removed from the water completely. Heretofore the only known method of removing sodium bicarbonate from water was by distillation. Hydrogen zeolite is the first chemical method to accomplish the same result. There are many municipal and private water supplies that contain sodium bicarbonate. Hydrogen zeolite will prove of benefit for the conditioning of such waters.

2) *Removal of calcium and magnesium bicarbonate.* As reaction (3) also shows, hydrogen zeolite converts calcium or magnesium bicarbonate into carbonic acid, which is removable by a cold degasi-

fier. Heretofore, sodium zeolite merely converted the calcium and magnesium bicarbonate into sodium bicarbonate. Hydrogen zeolite goes a step further and not only removes the calcium and magnesium cations as completely as sodium zeolite did in the past, but converts these calcium and magnesium bicarbonates into carbonic acid, which is removable. Consequently, the hydrogen zeolite not only removes the hardness, but also removes the alkalinity as completely as desired.

Because of the above two effects, hydrogen zeolite will find application in the following cases:

1) *Municipal Water Softening.* The first method employed in municipal water softening was the cold lime treatment method. This precipitated the bicarbonate hardness as calcium carbonate and magnesium hydrate. The disposal of the precipitates formed presented a problem. Many municipalities have no large river into which such precipitates or sludge may be discharged. Consequently, the sludge is stored in pits and must be carted away. Even if streams are available for disposal of sludge, the discharge of sludge at times of low water causes deposit in the bed of the stream. Then when freshets come along, the sludge is suddenly picked up and creates a nuisance downstream.

Because of this problem of sludge disposal, sodium zeolite for municipal water softening became quite popular and an increasing number of such plants have been installed in the last few years. No sludge is created and the waste brine used in regeneration is a clear liquid that can be disposed of without nuisance.

The use of lime for municipal water softening has the advantage over sodium zeolite of decreasing the alkalinity of the water. The sodium zeolite merely converts the calcium and magnesium bicarbonates into sodium bicarbonate, but the total amount of bicarbonate anion remains unchanged. Where the amount of bicarbonate present is appreciable, most industrial users of the treated water would prefer a water of lower alkalinity.

Hydrogen zeolite, according to reaction (3), converts the bicarbonates into carbonic acid. This in turn is removable from the water by a cold degasifier. Therefore, the bicarbonates are completely removed from the water without the formation of any sludge. Thus hydrogen zeolite presents a new method for municipal water softening, combining the advantage of lime, which reduces the alkalinity, with the advantages of zeolite, which removes the hardness without the production of any sludge.

2) *Recarbonation of lime-treated waters.* Another application of hydrogen zeolite, which is of interest in the municipal treatment field, is the use of the hydrogen zeolite effluent for recarbonation of lime-treated water. The older methods of recarbonation involved the production of flue gas in some type of a furnace and pumping the flue gas by a compressor into the lime-treated water.

The effluent of a hydrogen zeolite softener contains a fairly constant content of free CO_2 in solution. It may therefore be satisfactorily employed for recarbonation because the proportioning problem is simplified. The only control required is the regulation of the rate of flow of the H_2Z effluent in proportion to the rate of flow of the water to be carbonated and this is a much simpler regulation than controlling the CO_2 content of the flue gas and controlling the rate of flow of the gas. Case #3 illustrates a plant in actual operation.

TABLE 4

Case 3. Zeo-Karb H used in recarbonation of lime treated water village in middlewest

Results in p.p.m.

	Raw water	Lime soda effluent	Zeo-Karb effluent	Mixture 90 per cent L.S. 10 per cent Zeo-K	Filtered
Total hardness as $CaCO_3$	456	85	2	76	74
Ca hardness as $CaCO_3$	264	45	1	40	39
Mg hardness as $CaCO_3$	192	40	1	36	35
xMethyl alk. as $CaCO_3$	336	114	0	80	78
Phenol alk. as $CaCO_3$	0	77	0	15	14
Caustic alk. as $CaCO_3$	0	40	0	0	0
Free CO_2 as CO_2	40	0	295	0	0
Free mineral acidity as $CaCO_3$	0	0	200	0	0
xChlorides as NaCl	8	8	8	8	8
xSulfates as Na_2SO_4	300	300	300	300	300
Total solids (items x)	644	422	308	388	386

A municipal cold continuous Lime-Soda softener was installed in a midwestern village in 1937. The capacity is about 100,000 gallons per day. A portion of the raw water (about 10 per cent) is passed through a 24-inch diameter Zeo-Karb H unit. The Zeo-Karb H

effluent is mixed with about 90 per cent of the Lime-Soda-treated water to recarbonate and stabilize it. Table 4 gives the chemical results. Since the Zeo-Karb H effluent has a hardness approaching zero, the mixture has a lower hardness than the Lime-Soda-treated water. The hydrates in the lime-soda-settled water are thus changed, partly to carbonates and partly to bicarbonates before filtration. The final effluent is therefore stable and the pH value may be regulated at will by varying the percent of raw water passed through the Hydrogen Zeolite unit.

The advantages of hydrogen zeolite as compared with blowing scrubbed flue gas into lime-treated water for recarbonation are:

1) It avoids the problem of combustion.

2) It avoids the problem of disposing of the heat of combustion economically.

3) It avoids the problem of maintaining constant CO_2 content in the flue gas.

4) It avoids the use of a scrubber to wash and clean the flue gas.

5) It is easier to proportion the flow of hydrogen zeolite effluent to the flow of lime-treated water than to proportion the flow of flue gas to the flow of lime-treated water.

6) It saves a blower and pipe grid and avoids introducing oxygen and other gases present in the flue gas into the water.

7) It reduces the size of carbonation chamber from 20 to 30 minutes retention period down to several minutes retention. Very little time is needed to mix the hydrogen zeolite effluent with the lime-treated water. They are both liquids and the mineral acidity and the carbonic acid are in solution and react instantaneously with the hydrates in the lime-treated water.

The per cent of raw water to be passed through the hydrogen zeolite is calculated as follows:

$$\%\ H_2Z\ \text{effluent} = 100 \times \frac{K + \text{Alk C}}{\text{Alk C} + \text{FMA} + 2.3 \times CO_2}$$

Where K = a constant, usually 0 to 40

Alk C = p.p.m. of hydrate alkalinity (as $CaCO_3$) in the lime-treated water.

FMA = p.p.m. of mineral acidity (as $CaCO_3$) in the H_2Z effluent.

CO_2 = p.p.m. of free CO_2 (as CO_2) in the H_2Z effluent.

3) *Raw water ice manufacture.* In the manufacture of raw water ice, it is important that the water supply be as low in total solids as

possible, because these dissolved solids affect the transparency of the ice. But the bicarbonates of calcium, magnesium and sodium are more objectionable from this point of view than the chlorides and sulfates. Sodium bicarbonate is further objectionable because it tends to make a brittle ice unless the ice is frozen very slowly, which affects the capacity of the ice factory. The following case history illustrates the use of a hydrogen zeolite unit to remove practically all of the bicarbonates in a high sodium bicarbonate water.

Case #4 illustrates the use of a hydrogen zeolite unit in a raw water ice plant.[1] The water in this case comes from a 1000 ft. deep well. The water contained 705 p.p.m. of sodium bicarbonate.

TABLE 5

Case 4. Zeo-Karb H used in raw water ice plant
Typical chemical results in p.p.m.

	WELL WATER	ZEO-KARB H EFFLUENT	AFTER MIXING 3/4 ZEO-KARB EFFLUENT WITH 1/4 RAW WATER
Total hardness as $CaCO_3$	0	0	0
xMethyl orange alkalinity as $CaCO_3$	460	0	45
Phenol alkalinity as $CaCO_3$	20	0	0
xChlorides as NaCl	89	89	89
xSulfates as Na_2SO_4	62	62	62
Mineral acidity as $CaCO_3$	0	95	0
Free CO_2 as CO_2	0	388	20
Total solids (items x)	611	151	196

It was not possible to make merchantable ice from this water. The ice was too brittle and snowy in appearance. A more suitable water was transported from some distance by barge. A Zeo-Karb H unit was installed in 1936 to treat the original water to eliminate the cost of transporting the distant water. The sodium bicarbonate of the original well water was practically eliminated. Table 5 gives the actual chemical results. The water thus treated yields a perfectly transparent and satisfactory ice even when freezing rapidly at 10°F and with a single drawing of a small core.

[1] For further detail see article in Industrial & Engineering Chemistry, January, 1938, Page 80,—"Zeo-Karb H—A New Method of Conditioning Water to Remove Sodium Bicarbonate Chemically instead of by Distillation" by S. B. Applebaum & R. Riley.

4) *Carbonated Beverage Industry.* Many of the carbonated beverages manufactured in this country have a slightly acid content in order to contribute a tang and refreshing flavor, and also to preserve the beverage from the growth of molds or bacteria. It is important, therefore, that the water supply from which the beverage is made, should have a low alkalinity, so as not to neutralize this acidity. The water used for many types of carbonated beverages should contain a total methyl orange alkalinity of less than 85 p.p.m. expressed as $CaCO_3$. Some beverages even require an alkalinity under 50 p.p.m. Hydrogen zeolite permits the production of a

TABLE 6

Case 5. Zeo-Karb H unit used in southern carbonated beverage plant

Results in p.p.m.

	RAW CITY WATER	ZEO-KARB H EFFLUENT	MIXTURE OF 36 PER CENT RAW AND 64 PER CENT ZEO-KARB
Total hardness as $CaCO_3$	70	2	25
Ca hardness as $CaCO_3$	46	1	17
Mg hardness as $CaCO_3$	24	1	8
xMethyl alkalinity as $CaCO_3$	240	0	44
Phenol alkalinity as $CaCO_3$	0	0	0
Sodium alkalinity as Na_2CO_3	180	0	20
Free CO_2 as CO_2	20	230	154
Free mineral acidity as $CaCO_3$	0	65	0
xChlorides as NaCl	77	77	77
xSulfates as Na_2SO_4	9	9	9
Total solids (items x)	326	86	130

treated water of any alkalinity that may be desired. It avoids the use of chemical feeds and settling tanks and filters for the removal of the precipitates formed by the addition of such chemical reagents. It therefore occupies very much less space than a typical lime treatment plant and this is important because space is usually at a premium in bottling establishments. The following case (#5) illustrates the application of a small hydrogen zeolite unit in the plant of a Southern bottling company.

The raw water in this case comes from the city deep wells and there is considerable sodium bicarbonate present, as shown in column 1

of table 6 attached. About 64 per cent of the water will pass through the Zeo-Karb H unit and 36 per cent will bypass around the unit. The mixture will have the analysis shown in column 3 of table 6 attached. The CO_2 present in this mixture will not be removed by a degasifier because in a carbonated beverage plant CO_2 is added to the water in the process of manufacture and therefore the CO_2 present in the mixed effluent is useful and should not be removed. The mixed water will therefore be passed directly into the carbonator and filler machine.

It will be noted from table 6 that the alkalinity will be reduced from 240 p.p.m. down to 44 p.p.m. and the total solids will be reduced from 326 p.p.m. to 130 p.p.m. The resulting effluent will be perfectly suited for the manufacture of carbonated beverages.

5) *Boiler Feedwater Treatment.* The history of boiler feedwater treatment may be briefly summarized by stating that it has been the continuous endeavor of the chemists who have developed new methods of treatment, to aim at the lowest possible hardness and total solids in the final effluent and at the same time accomplish this with the lowest possible residual alkalinity in the treated water. The first form of treatment known was the cold lime and soda treatment. By this it was possible to accomplish a reduction in the hardness down to about 68 p.p.m. as $CaCO_3$, with an excess of soda ash of about 34 to 50 p.p.m. In order to obtain a still lower hardness with a still lower excess of soda ash, the hot lime soda treatment was the next step. With this method of treatment it was possible to reduce the hardness down to 17 to 26 p.p.m. with an excess of soda ash of 26 to 34 p.p.m.

The sodium zeolite method has been used to a great extent also, because the hardness could be reduced to practically zero. But as stated previously, the bicarbonates of calcium and magnesium were converted into sodium bicarbonate, so that the alkalinity was not reduced. Therefore, in many cases sulfuric acid feeds were added after the sodium zeolite units to convert the sodium bicarbonate to sodium sulfate. In other cases cold lime pretreatment followed by acid preceded the zeolite.

Hydrogen zeolite is the next step in the constant endeavor, mentioned above, to produce a treated water of lowest hardness and at the same time, lowest alkalinity. During the few years since it has been introduced, a considerable number of boiler plants have adopted

TABLE 7

Partial list of Permutit Zeo-Karb H plants

USER	STATE	TYPE ZEOLITE	TREATING CAPACITY LB./HOUR	USE OF EFFLUENT	POUNDS BOILER PRESSURE
Ice plant	Maryland	H	5,500	Ice manufacturing	
U. S. Army post	Pennsylvania	H	3,300	Boiler feed	
Industrial steam plant	Pennsylvania	H	50,000	Boiler feed	600
Smelting plant	New Jersey	H, Na	90,000	Boiler feed	450
Paper pulp manufacturer	Florida	H	120,000	Boiler feed	400
Large public utility	Nebraska	H, Na	400,000	Boiler feed	475
Ice plant	Florida	H	4,200	Ice manufacturing	
Manufacturer	New York	H, Na	25,000	Boiler feed	
Paper manufacturer	Michigan	H, Na	42,000	Boiler feed	615
Village	Ohio	H	3,000	Neutralizing lime soda effluent	
City	Wisconsin	H	5,000	Boiler feed	
Paper manufacturer	Wisconsin	H, Na	100,000	Boiler feed	650
Ice manufacturer	Missouri	H	2,000	Ice manufacturing	
Carbonated beverage	Texas	H	5,000	Carbonated beverage	

this form of treatment. Table 7 gives a partial list of such plants, their capacity and the boiler pressure. The reasons for the progress in the adoption of hydrogen zeolite are:

a) It produces a water of lower total dissolved solids than by any other treatment except distillation. With waters that are fairly low in chloride and sulfate content and consist mainly of bicarbonate alkalinity, the effluent of hydrogen zeolite compares very favorably with distilled water. This is especially true when it is considered that many boiler feed plants employing distilled water add to it alkali to raise the pH value and sodium sulfate to increase the sulfate-carbonate ratio, and when these additional reagents are considered, the composition of the modified distilled water resembles the effluent of hydrogen zeolite plants.

b) It permits the production of steam from boilers of lowest possible CO_2 content. It is rapidly becoming recognized that it is important to keep the CO_2 content of the steam down to a minimum, because the CO_2 content decreases the pH value of the condensate formed from the steam and this accelerates the corrosion that occurs in condensate return systems. This is especially important in the central heating field. For example, recently one of the large central heating companies in the middle west decided to increase the addition of acid after the sodium zeolite treatment so as to reduce the CO_2 content of their steam sold to consumers for heating purposes, to approach zero as far as possible. The practice heretofore has been to maintain the CO_2 content of the steam under 20 p.p.m., but it has been found that this is not sufficient protection against corrosion of condensate return systems. Therefore, this additional plant, consisting of a second acid feed plus a degasifier ahead of the deaerating heater, has been installed in this central heating company for the purpose of reducing the CO_2 content of the steam to the minimum. The same consideration applies to individual boiler plants, as well as to central heating plants.

The amount of CO_2 formed in the steam is directly affected by the alkalinity of the feedwater. 1 p.p.m. of sodium carbonate alkalinity (expressed as $CaCO_3$) forms about 0.4 p.p.m. of CO_2 in the steam. 1 p.p.m. of sodium bicarbonate alkalinity (expressed as $CaCO_3$) forms 0.79 p.p.m. of CO_2 in the steam. The effluent of the average hot lime soda plant contains between 25 and 30 p.p.m. of soda ash and therefore with 100 per cent makeup, the CO_2 in the steam using this feedwater, would be 10 to 12 p.p.m. When phosphate is added

as a secondary treatment, which is often the case after hot lime soda, the phosphate reacts with the calcium carbonate present in the feedwater to form more soda ash and this still further increases the CO_2 content of the steam.

In the case of sodium zeolite softeners, the CO_2 content of the steam would depend entirely on the sodium bicarbonate alkalinity in the effluent. Sulfuric acid may be added either to the effluent of the hot lime soda softener or a sodium zeolite softener to reduce the alkalinity and thereby reduce the CO_2 in the steam, but the reaction between acid and sodium bicarbonate is as follows:

$$2\,NaHCO_3 + H_2SO_4 = Na_2SO_4 + 2\,H_2O + 2\,CO_2$$

Therefore, an equivalent amount of sodium sulfate is formed in the place of the sodium bicarbonate. This increases the total solids and involves the addition of acid directly to the feedwater.

The hydrogen zeolite accomplishes the maximum reduction in alkalinity without the formation of any equivalent amount of sodium sulfate. It is even possible to reduce the alkalinity to zero and thereby insure zero CO_2 in the steam, with zero hardness in the feedwater, which cannot be produced without increasing total solids by any method other than hydrogen zeolite. It is thus possible to produce steam from boilers with zero CO_2 or approaching zero CO_2, which particularly appeals to boiler users, especially for high pressure boilers.

CONTROL OF ALKALINITY IN ZEO-KARB EFFLUENTS

As reactions 4 and 5 show, the sulfates and chlorides in the raw water are converted to equivalent amounts of sulfuric acid and hydrochloric acid in the effluent of hydrogen zeolite units. If the chlorides and sulfates are expressed as $CaCO_3$ for convenience, then the sum of these two constituents may be called the Theoretical Mineral Acidity (ThMA). Actually the effluent of hydrogen zeolite units does not contain as much acidity as this ThMA. The actual acidity, called Free Mineral Acidity (FMA) is slightly less than the ThMA. This FMA in the effluent of hydrogen zeolite units remains fairly constant throughout a run of the hydrogen zeolite unit from one regeneration to another. Fig. 3 gives a typical curve of performance. It is to be noted that the acid used in regenerating the unit is rinsed out and the rinsing continues down to a point slightly below the ThMA. The actual Free Mineral Acidity then continues constant

until near the end of the run, when it begins to decrease. The regeneration is administered to the unit when this FMA of the effluent decreases to an appreciable extent. It is to be noted also that the hardness of the hydrogen zeolite unit remains practically at zero throughout the run and, in fact, when regeneration takes place due to the drop in the FMA, there is usually still additional capacity for hardness removal left, as indicated in this typical curve.

In order to neutralize this FMA in the effluent of the hydrogen zeolite unit, it is usually customary to have a sodium zeolite unit operating in parallel with the hydrogen unit. Then the sodium

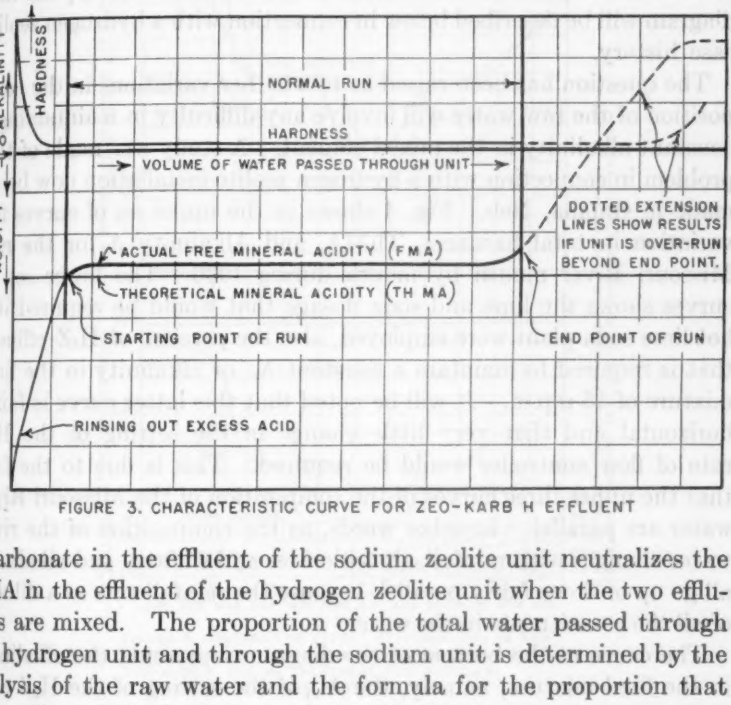


FIGURE 3. CHARACTERISTIC CURVE FOR ZEO-KARB H EFFLUENT

bicarbonate in the effluent of the sodium zeolite unit neutralizes the FMA in the effluent of the hydrogen zeolite unit when the two effluents are mixed. The proportion of the total water passed through the hydrogen unit and through the sodium unit is determined by the analysis of the raw water and the formula for the proportion that passes through the hydrogen unit is as follows:[2]

$$\% \ H_2Z \text{ effluent} = 100 \times \frac{A_r - A_m}{A_r + FMA}$$

[2] For derivation of this formula, see paper to be presented by H. L. Tiger, Vice President, The Permutit Co. before the A. S. M. E. meeting in St. Louis in June, 1938, entitled: "Carbonaceous Zeolites—An Advance in Boiler Feed-water Conditioning." (Trans. A. S. M. E., 60: 315 (1938).)

Where A_r represents methyl orange alkalinity in the raw water (expressed as $CaCO_3$); A_m represents the desired methyl orange alkalinity in the final mixed effluent.

All that is required, therefore, to maintain a constant alkalinity in the final mixed effluent is to control the rates of flow of the hydrogen zeolite effluent and the sodium zeolite effluent in the correct proportion to each other, mix the two and then pass the mixture through a degasifier for the removal of the free CO_2 present in the hydrogen zeolite effluent as well as the CO_2 formed by the reaction between the mineral acidity of the hydrogen zeolite effluent and the sodium bicarbonate of the sodium zeolite effluent. A typical flow diagram will be described below in connection with a hydrogen zeolite case history.

The question has been raised as to whether variations in the composition of the raw water will involve any difficulty in maintaining a constant alkalinity in the mixed effluent. A study was made of this problem in connection with a hydrogen zeolite installation now being made in Omaha, Neb. Fig. 4 shows in the upper set of curves the variation in total hardness, ThMA, and Alkalinity A for the raw Missouri River month by month during 1936. The lower set of curves shows the lime and soda dosage that would be required if a hot lime soda plant were employed, also the percent of H_2Z effluent that is required to maintain a constant A_m or alkalinity in the final mixture of 15 p.p.m. It will be noted that this latter curve is fairly horizontal and that very little change in the setting of the H_2Z rate of flow controller would be required. This is due to the fact that the upper three curves of the composition of the Missouri River water are parallel. In other words, as the composition of the river water changes with rainfall, the chlorides and sulfates and alkalinity all go up or down fairly parallel, because the rainfall acts as a diluent of all the constituents in the water.

The curve at the bottom of the diagram represents the alkalinity in the final mixture, namely, the A_m, if the setting of the H_2Z controller were kept constant at 40 percent without making any changes for variations in raw water composition and it will be noted that this A_m stays fairly constant throughout the year.

We have been conducting considerable research in the design and operation of the degasifiers in order to remove the free CO_2 from the mixed effluent. The design finally worked out will permit the production of a final effluent with a CO_2 content of 5 to 10 p.p.m.

As a typical illustration of a hydrogen zeolite plant, Case #6 is described herewith.

This is a new boiler plant, boiler pressure 650 pounds—makeup 30 per cent. The water comes from a river and is filtered for general process work throughout the mill. The filtered water will be passed through the Zeo-Karb units, a degasifier and then into a deaerator.

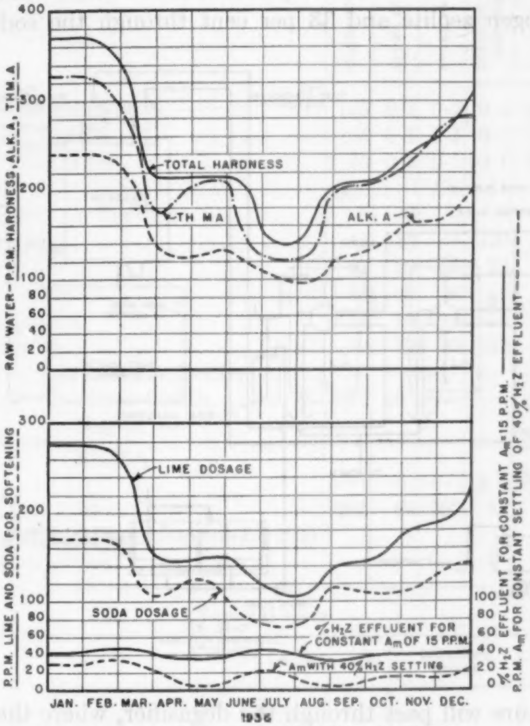
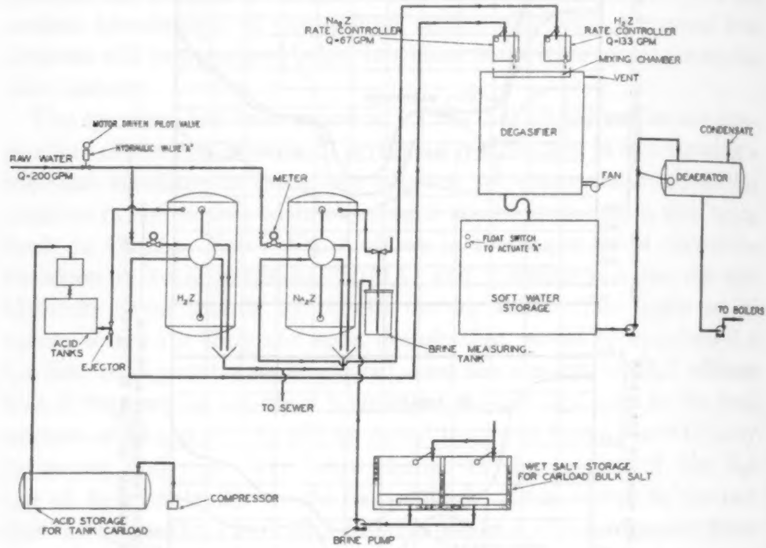


FIGURE 4. COMPARATIVE EFFECT OF VARIATIONS IN RAW WATER COMPOSITION ON LIME-SODA TREATMENT AND ZEO-KARB H AND NA TREATMENT FOR MISSOURI RIVER WATER AT OMAHA, NEBRASKA.

Table 8 gives the analysis of the water at various stages of treatment. In this table we have also indicated the probable analysis if a hot lime soda plant had been installed. It will be noted that the total dissolved solids anticipated after the Zeo-Karb treatment will be 83 p.p.m. and after hot lime soda would have been 152 p.p.m., due to the fact that sodium sulfate would have to be added to establish

a 3:1 sulfate-carbonate ratio. The percent of blowoff will be reduced as indicated in this table. Comparative operating costs are likewise shown. One of the considerations in this particular case that favored Zeo-Karb treatment was the need for cold treated water to quench a number of vacuum pumps handling condensate. The effluent of a hot lime soda plant would have been too hot for this purpose.

Fig. 5 illustrates the general arrangement of the Zeo-Karb plant. It is to be noted that about 67 per cent of the water will flow through the hydrogen zeolite and 33 per cent through the sodium zeolite.



CASE 6
ZEO-KARB H PLANT
FIGURE #5

The mixture will pass through the degasifier, where the CO_2 will be reduced from about 120 down to 10 p.p.m. and then the degasified water will flow into the storage tank. Acid and salt will be stored in carload lots to reduce operating cost to the minimum. The acid handling and salt handling equipment are shown in the diagram.

6) *Other Applications for Hydrogen Zeolite.* Reduction of alkalinity is also of importance in a number of industries, such as leather and paper manufacture, metal plating, certain classes of textile dyeing, cooling water treatment, etc.

TABLE 8

Case 6. Zeo-Karb H and Na used for boiler feed treatment in Western Paper Mill
Chemical results in p.p.m.

	FILTERED RIVER	AFTER ZEO-KARB H	AFTER ZEO-KARB Na	MIXTURE 1/3 Na 2/3 H BEFORE DEGAS	AFTER DEGASIFICATION	AFTER DEAERATOR	COMPARATIVE HOT LIME SODA PLUS Na_2SO_4
Total hardness as $CaCO_3$	175	0–2	0–2	0–2	0–2	—	26
Ca hardness as $CaCO_3$	105	0–1	0–1	0–1	0–1	—	17
Mg hardness as $CaCO_3$	70	0–1	0–1	0–1	0–1	—	9
xM.O. alkalinity as $CaCO_3$	134	0	134	15	15	—	52
Phenol alkalinity as $CaCO_3$	0	0	0	0	0	—	26
Free CO_2 as CO_2	15	133	15	120	10	0	0
xChlorides as NaCl	22	22	22	22	22	—	22
xSulfates as Na_2SO_4	46	46	46	46	46	—	78
Chlorides as $CaCO_3$	18	18	18	18	18	—	—
Sulfates as $CaCO_3$	32	32	32	32	32	—	—
Theor. min. acid. (ThMA) as $CaCO_3$	50	—	—	—	—	—	—
Free min. acid (FMA) as $CaCO_3$	45	45	—	—	—	—	—
Sulfate Carbonate $\frac{Na_2SO_4}{Na_2CO_3}$	—	—	—	3.0	3.0	—	3.0
pH value	—	—	—	5.5	6.6	8.3	10
Total solids (items x)	202	68	202	83	83	—	152
Per cent blowoff in terms of makeup for 2500 p.p.m. T.S. in saline	—	—	—	—	35	3.5	6.5

Chemical costs

	LB./1000 GALS.	COST/LB., CENTS	COST/1,000 GALS., CENTS
Zeo-Karb:			
Salt	1.66	0.5	0.83
Acid	1.83	1.0	1.83
			2.66
Hot lime soda:			
Lime	1.28	0.6	0.77
Soda ash	0.58	1.5	0.87
Sodium sulfate	0.27	1.5	0.40
			2.04

ANION REMOVAL

Hydrogen zeolite has brought us to a point in the field of water treatment of removing the calcium and magnesium cations completely and of removing the bicarbonate anions completely. The next step will be a zeolite for the removal of the chlorides and sulfate anions. Considerable research work has already been done in this direction.

Such chloride and sulfate anion removal can be accomplished in the second step of a two step process, which process we have called "Demineralizing" the water.

Step #1. Passing the raw water through hydrogen zeolite (Zeo-Karb H) resulting in reactions (3), (4) and (5) given above. The carbonic acid is removable by degasification after Step #2. The chloride and sulfate anions present as HCl and H_2SO_4 in the effluent of Step #1 are removed in Step #2.

Step #2. The effluent of Step #1 passes through a special material which removes the HCl and H_2SO_4. This material is regenerated with NaOH or Na_2CO_3.

Adams & Holmes[3] described various synthetic resins which can function in Step #1. Zeo-Karb H must not be confused with such synthetic resins. We have found Zeo-Karb H not only to be more suitable, but to be much less costly both to manufacture and to operate than these resins.

We have installed a number of small two step demineralizing plants in various parts of the country. After a successful proving period in the field, this method will be available for commercial application to produce an effluent approaching distilled water in purity, even when chloride and sulfate anions are present in the untreated water.

SUMMARY

The carbonaceous zeolite now in commercial application (Zeo-Karb) consists mainly of carbon and is non-siliceous. It is made from carbonaceous material, such as coal, by special treatment with sulfuric acid, etc. All previously known sodium zeolites had a considerable content of silica and should therefore be classified as siliceous zeolites.

Carbonaceous zeolite may be used in the sodium zeolite cycle,

[3] See Journal of Society of Chemical Industries, January 11, 1935.

that is, regenerated with sodium chloride. Its industrial guaranteed capacity then is 5,000–8,000 grains of $CaCO_3$ removed per cu. ft. when using 0.35 to 0.50 pound of salt per 1,000 grains of hardness removed. It is resistant to aggressive, low pH waters and because of its large granule size, can handle high flow rates—6 to 8 gallons per minute per square foot with low loss of head.

Due to its resistance to acid, it can also be regenerated with sulfuric acid to form hydrogen zeolite. Its industrial capacity in the hydrogen zeolite cycle is 8,000 to 9,000 grains of cation (Ca + Mg + Na expressed as $CaCO_3$) when using 2.25 to 3.0 pound H_2SO_4 per cubic foot of Zeo-Karb H. The reactions of hydrogen zeolite softening are given and they show that calcium, magnesium and sodium bicarbonates are converted into carbonic acid, which, in turn, may be removed from the water by a cold degasifier or an open heater.

Carbonaceous sodium zeolite (Zeo-Karb Na) is applicable for waters of low pH value, waters high in iron, waters low in silica and especially in cases where space is limited.

Two case histories are given of large plants that are using Zeo-Karb Na for softening after a preliminary silica removal treatment of the water.

Hydrogen zeolite (Zeo-Karb H) not only removes calcium and magnesium bicarbonates, but also removes sodium bicarbonate, converting them into carbonic acid, which is removable by a cold degasifier. The removal of sodium bicarbonate in this manner is the first chemical process that has thus far been developed for this purpose outside of distillation.

Hydrogen zeolite softeners, therefore, find application in boiler feed treatment, in municipal water treatment for the removal of bicarbonates, in the recarbonation of lime-treated water, in the manufacture of raw water ice and carbonated beverages and in other industries where the removal of sodium, calcium and magnesium bicarbonates is of importance. Case histories are given of a raw water ice plant and a carbonated beverage plant that have installed hydrogen zeolite units for this purpose. A list of hydrogen zeolite units for boiler feed and other purposes is given. A case history of a typical boiler feedwater treatment plant by hydrogen zeolite is also given. Hydrogen zeolite permits the production of a water of lowest total solids, lowest alkalinity and the lowest possible CO_2 content in the steam generated by the boiler.

Anion removal for the elimination of chloride and sulfate anions

is briefly discussed and the carbonaceous zeolites described in this paper are distinguished from the synthetic resins discussed by Adams and Holmes.

Discussion by A. S. Behrman.[4] It is simply stating the obvious to say that Mr. Applebaum has presented a most interesting and informative paper for which he is to be commended; and commendation should also be given, I believe, to his company for its part in endeavoring to popularize in this country these "carbonaceous zeolites" which originated in Europe quite a few years back. Our own organization is likewise quite enthusiastic about these materials and their possibilities in the water purification art; and we have therefore felt warranted in devoting a great deal of time and effort in research and development along these lines in the past few years. Our enthusiasm, however, is somewhat tempered by a full realization of their limitations, especially when utilized for hydrogen exchange—limitations which are likely to be overlooked in the first flush of enthusiasm over any innovation in any art. Since Mr. Applebaum's paper has dwelt almost exclusively on the advantages to be gained from the use of these materials, possibly the best service this brief discussion of mine can render will be to call attention to some of the more important limitations which should be borne in mind in connection with their use.

First, however, I believe it only fair to all concerned, and particularly to the prospective user of these carbonaceous zeolites, that I give the same answer in public that I have given in private to a question that has been asked me several times in the past. This question concerns the patent situation connected with these carbonaceous materials. Let me say therefore, in entire frankness, that as a result of our own experience in the Patent Office in the past few years in an effort to translate the results of our research into some degree of domination in this field, we have come to the conclusion that no one can broadly patent these carbonaceous zeolites, or their use in either hydrogen or sodium exchange. It is to be expected, of course, that perfectly valid patents will issue on specific improvements in materials and in methods of application and utilization; but we are convinced that no one can monopolize broadly the manufacture of these products or their use as hydrogen or sodium zeolites. Evidently the same opinion is held more or less generally in well-informed

[4] Chemical Director, International Filter Co., Chicago, Illinois.

circles; for not only are there now on the market the "Zeo-Karb" of Mr. Applebaum's company, and "Catex" (Cation Exchanger) of our own organization, but at least one or two other competitive carbonaceous products are appearing on the horizon.

The one field for which hydrogen zeolites are preëminently suited is in the treatment of waters containing considerable amounts of sodium bicarbonate; and it is in this field that they may be expected to find their most successful work. It would be improper to assume, however, that the mere fact that a water contains appreciable quantities of sodium bicarbonate will require perforce a recommendation for hydrogen zeolite treatment. As a matter of fact, experience has already shown that even with sodium bicarbonate waters, a combination of other considerations, such as the character of the water, engineering factors, and the use to which the treated water is to be put, may make some other type of water treatment the most logical and desirable choice.

When all is said and done, treatment with lime is still the cheapest and safest method of removing calcium and magnesium bicarbonates; and the flexibility of the treatment, and the concomitant benefits accruing from its use, give it certain definite advantages over sodium zeolite or hydrogen zeolite treatment in many types of work. It is to be expected, on the other hand, that there will be found combinations of circumstances where hydrogen zeolite treatment becomes the logically indicated procedure, even though lime (or lime-soda) treatment would at first glance appear to be better inherently adapted to the water in question.

This is another way of saying, of course, that no short cut has yet been found which will avoid the necessity of a painstaking analysis of all the factors involved in practically every water problem that is encountered, arriving at a decision only after a careful balancing and evaluation of all these factors.

The need for such a careful analysis may be well exemplified by referring to two of the uses of hydrogen zeolite treatment described by Mr. Applebaum—for the treatment of waters for carbonated beverages, and for boiler feed water purification.

The reduction of alkalinity in water to be used for beverages is particularly to the point. Hydrogen zeolites are regenerated with sulfuric acid. The handling of concentrated sulfuric acid involves a genuine hazard to the handler, particularly to the unskilled operator who has not been trained to have the chemist's wholesome respect

for this reagent. Moreover, in the method of operation outlined by Mr. Applebaum, the effluent from the hydrogen zeolite contains free mineral acidity corresponding roughly to the chlorides and sulfates in the raw water, this acidity requiring the addition of some type of alkalinity to neutralize it. Using the method of operation as outlined, there is thus introduced the unpleasant possibility of having free sulfuric or hydrochloric acid (either from the regenerating solution or from incompletely neutralized acid) escaping into the house system to corrode metallic surfaces with which it comes in contact and, of obviously greater importance, into the finished beverage itself, to be taken internally in due course by the consumer.

It is possible to operate these hydrogen zeolite plants on what we like to call a "selective exchange" or "minimum acid consumption" basis. With this method of operation the regenerating acid is almost, if not completely, used up in the regeneration; and the treated water, during the purification run proper, not only contains no mineral acidity but is actually slightly alkaline, this alkalinity being maintained within any reasonable limit. When it becomes possible to supplement this method of operation with sufficiently automatic and foolproof controls, the hazards of hydrogen zeolite treatment in the bottling plant will be largely eliminated, and a more favorable reception of the method will undoubtedly and deservedly be forthcoming. In the meantime, it is worth remembering that the present standard method of reducing alkalinity (due to calcium and magnesium bicarbonates) with lime not only produces just about as low a residual alkalinity as can safely be carried out with the hydrogen zeolite treatment, but also makes it possible to accomplish simultaneously several other kinds of purification—extremely important in some instances, not at all important in others—which are altogether beyond the scope of the hydrogen zeolite treatment.

In the field of boiler feed water treatment, particularly in the large, modern power plants adequately manned by trained technicians, the hazard in handling sulfuric acid should become practically a negligible factor. The necessity for very careful control of the treated water obviously still remains, in order to avoid the possibility of a seriously destructive effect on the boilers and accessory equipment.

As a step in the direction of increased safety and efficiency, it will be of interest to mention the two-stage process we have developed. In the first, or hydrogen exchange stage, the carbonaceous zeolite is operated on the "selective exchange" or "minimum acid

consumption" basis previously described. The treated water from this stage is slightly alkaline, with a total hardness which is the sum of the residual carbonate hardness plus all the non-carbonate hardness of the raw water. This effluent from the first stage is subsequently passed through a bed of zeolite (preferably, also, carbonaceous) regenerated with sodium chloride, and is completely softened in consequence. Incidentally, if through accident or gross carelessness some free mineral acidity should appear in the effluent from the first stage, this acidity will be removed by sodium exchange in the second stage.

While hydrogen zeolite treatment will undoubtedly have a place in the boiler feed water treatment picture, I have the feeling that, after hydrogen zeolites have been in use long enough to permit their proper evaluation, hot-process lime-soda softening will be found still holding its own without much difficulty.

Time will not permit a more detailed discussion of Mr. Applebaum's paper on these intriguing carbonaceous materials, or of our own work with them, or of their possible applications in still unexplored fields. Suffice it to say, therefore, in closing, that I am sure that Mr. Applebaum will agree that there is still a great deal to be found out about hydrogen zeolites and their applications. In the meantime, it seems to me that the proper attitude to take is that water purification practice has a new medicine in its kit—a strong medicine, which, like strong liquor, should be used with discretion.

Discussion by S. B. Applebaum. I wish to thank Mr. Behrman and the company of which he is chemical director, for the interesting discussion which he contributed on the subject of Carbonaceous Zeolites.

I regret, however, that he has introduced the question of patents into a technical discussion, because obviously patent matters should be handled in the Patent Office. I cannot agree with Mr. Behrman as to his conclusions with regard to the patents on Carbonaceous Zeolites.

As regards the hazards emphasized in the discussion,—in treating water by hydrogen zeolite, it is to be noted that the acidity in the effluent of the hydrogen zeolite is approximately equal to the chlorides and sulfates in the raw water. Since most waters treated by this process will have a fairly low chlorides and sulfates, the total acidity in the effluent will be low, usually under 200 parts per million

and mostly under 100 parts per million. Furthermore, this acidity will be constant, because the hydrogen zeolite process consists of exchanging hydrogen for the cations Ca, Mg and Na. If these cations are combined with Cl and SO_4 anions, the effluent contains hydrochloric acid (HCl) and sulfuric acid (H_2SO_4) in amounts equal, approximately, to the Cl and SO_4 anions in the raw water. Due to the low acidity and the constancy of the acidity, our experience with a number of hydrogen zeolite plants in actual operation has shown that the problem of neutralizing this acidity is easily solved.

Regarding the method discussed by Mr. Behrman consisting of passing all the water through the hydrogen zeolite first and regenerating the hydrogen zeolite with less than the normal amount of acid (on the starvation basis, as we call it), and then passing the effluent of the hydrogen zeolite through sodium zeolite, we have devoted considerable research to this method and have had a full sized installation in operation for some time. The disadvantages which this method involves are:

(1) Much larger investment because both the hydrogen zeolite and sodium zeolite must be designed to handle 100 per cent of the flow, whereas in the method employing the full amount of acid for regeneration, a fraction of the total flow passes through the hydrogen zeolite and the remaining fraction through the sodium zeolite.

(2) When hydrogen zeolite is regenerated with less than the normal amount of acid (or on the starvation basis) and the effluent is passed through the sodium zeolite unit, the alkalinity of the final effluent is not constant.

(3) It will be necessary to degasify the carbon dioxide (CO_2) from the hydrogen zeolite effluent before passing it through the sodium zeolite.

A MODIFIED LACTOSE BROTH FOR USE IN THE PRESUMPTIVE TEST

By Philip B. Cowles

Department of Immunology, Yale University School of Medicine, New Haven, Connecticut

A substitute for or modification of the standard lactose broth used in sanitary water analysis which will reduce the number of false positive presumptive tests and yet exert no inhibition on the development of coliform bacteria is much to be desired. Numerous preparations have been suggested and tried. Of these some have given initial promise, but for one reason or another have failed to fulfill all requirements. The medium described herein may well have a similar fate, but tentative tests have suggested that it has distinct possibilities, and a description of it is given in the hope that it will be tried out and its merits and defects determined.

Standard lactose broth is used for the basic medium, and to this is added a small amount of an alkyl sulfate. The alkyl sulfates seem to prevent, by and large, the growth of Gram-positive organisms, including the lactose-fermenting aerobes and anaerobes, while the Gram-negatives are, in general, able to develop in the presence of relatively high concentrations of these substances. Studies of this problem will appear in a later paper.

Sodium lauryl sulfate is the most readily obtained pure compound, and most supply houses can furnish it for about $1.50 per pound. To each liter of standard lactose broth, 0.2 g. of the sulfate are added and the pH adjusted to 7.2 before tubing and autoclaving. Ordinary "Drene" shampoo can be substituted in an amount of 1.0 cc. per liter, adjusted to pH 7.4, and there is some evidence, in fact, that results with "Drene" are better. The finished medium looks exactly like the standard broth, but can easily be distinguished from it by the

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fact that a lasting foam develops upon shaking, due to the depressing action of the alkyl sulfate upon the surface tension.

As yet insufficient data have been accumulated to permit a definite evaluation of the medium, but the available figures, for the most part, indicate that no inhibition takes place in the growth of the coliform bacteria and that the number of false positives, particularly in the case of finished waters, is decreased very materially. If these results are confirmed in other parts of the country the medium should find a useful place in the armamentarium of the bacteriological water analyst.

WHAT ABOUT METER SPECIFICATIONS TODAY AND TOMORROW

A Round Table Discussion

By Clem A. Gallagher, F. W. E. Weisse and A. P. Kuranz

Clem A. Gallagher. Few specifications adopted sixteen years ago have remained unchanged in the intervening years. Nevertheless the A.W.W.A. standard specifications for cold water meters—disc type—are the same today as the day when adopted in June, 1921. There has been progress in every field of human endeavor in the post-war years, and the manufacture of water meters is no exception.

I firmly believe that the specifications as we know them today should be changed in several essential features. They should be brought up to date. Every year has added its share of experience, and experience points to progress and change. The studied avoidance of this issue will not contribute towards better meters, or more progressive waterworks.

Reverence for the old is one thing; idolatry of the old quite another. After all is said and done the waterworks men of today want the specifications to be such that they may be assured of receiving the

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Presented at the New Orleans convention, April, 1938. The participants were: Clem A. Gallagher, Superintendent of Services, Louisville Water Company, Louisville, Ky.; F. W. E. Weisse, Superintendent, Meter Department, Central Power and Light Company, Corpus Christi, Texas; and A. P. Kuranz, Superintendent, Water Department, Waukesha, Wisconsin.

Editor's Note: This discussion is published as a record of individual opinions and not as an official statement of the Association. The Water Works Practice Committee has fully recognized the timeliness of a careful reconsideration of the meter specifications. Mr. Samuel F. Newkirk, Superintendent of the Water Department of Elizabeth, New Jersey, has accepted the chairmanship and the committee is being organized in such a manner as to take into account the opinions of members over the entire country. The coöperation of the members of the Association with the committee is earnestly solicited. In reference to certain comments contained in the discussion relative to accuracy of meters, the suggestion may be made, from the producer's viewpoint, that the necessary differential in cost may be greater than some of the consumers are prepared to meet.

best meters that their money can buy. Our present specifications do not so assure them. It is my purpose to prove definitely from actual examples that the meter specifications in some essentials should be changed for the good of the waterworks field, as well as for the good of the manufacturer. I made this statement some years ago, and further detailed study and experimentation only make me firmer in my judgment.

The essentials looked for in any water meter are Endurance, Accuracy, and Interchangeability. That meter which will last the longest, register most accurately during this time, and can be repaired most economically when time or necessity dictates, is the meter desired by all buyers. It follows logically therefore that those specifications which would protect meter purchasers to the fullest extent under these three headings should be the specifications in force today. But are they?

If the specifications tomorrow are no more definite and complete, if they are not more exclusive and inclusive than today's, it is certain that retrogression, not progress, will be the result. The chaos, ill-feeling, cut-throat competition, and dissatisfaction in the meter field today can be traced very surely and honestly to the laxity of the specifications. Practically all water meter purchasers are not in a position to have qualified consulting engineers draw up proper specifications for any or all purchases, and as a result nearly all buyers depend on the A.W.W.A. specifications to guide them. The association owes it to these thousands of waterworks men, to leave nothing undone in making the meter specifications the most complete and concise that can be drawn up.

Actual conditions in the field today stand as vivid proof of the weakness and excessive latitude in today's meter specifications. Today instead of it being difficult to manufacture a meter to come up to A.W.W.A. specifications, it is very difficult to make a meter that will not fall within the specifications. The manufacturers know this, and in many instances their factory assemblage and testing equipment and standards are far more rigid than the specifications to be met. In general, they have the foresight to see the clouds of the day of reckoning rising slowly but surely, and have been forearming themselves.

When prices on $\frac{5}{8}$-inch meters meeting specifications, range in price from \$4.50 to \$12.00 it is self-evident that an essential discrepancy exists.

Today's meter specifications are so indefinite that exclusiveness is improbable, and all inclusiveness is practically mandatory. Today's specifications are not fair to either the waterworks man or to the manufacturer. Progress in the meter field has been evident in the last few years. Why not crown this movement with specifications worthy of our association.

Every displacement meter consists primarily of but four parts, a measuring chamber, a train of gears, a register and an outer casing enclosing the first mentioned three—The three essentials, mentioned before, endurance, accuracy, and interchangeability are dependent on all four above parts. The specifications outlining them should, therefore, be right to the point and decidedly protective.

As to the casing, all the specifications today say is that it "shall be of bronze composition." This statement provides us a good (?) start for bronze comes as we mortals do, good and bad. It is not even stated in today's specifications, that the casing should be of the best grade of bronze, ambiguous even as that is. In plain words, the cheapest grade of bronze obtainable, if it will hold together as a casing, meets the specifications.

Will a meter at $4.50 be encased in bronze of the same grade as a meter at $8.00 or $12.00? Which will endure longest? We simply have to use our heads for a moment in their natural function to conclude that the specifications should be specific. Only by stating a definite bronze composition will meter chaos and confusion be dispelled. Electrolytic action and kindred evils must be taken into experimental consideration before definitely deciding a composition or compositions, but "of bronze composition" is as specific as beef for hash. The same can be said in lesser degree of frost bottoms. If tests were made and a specific decided upon, many a replacement would be saved. "Cast-iron" is interpreted in a thousand different ways. For external bolts three alternatives are given, and "easy removal of the nuts after long service shall be designed." In what way? Does this not express a fond hope much more sincerely than a definite specification?

As far as the register and intermediate gear trains are concerned, the words used—"non-ferrous metals" are too ambiguous.

Without a doubt the most important word in the meter field in its literal and figurative sense is the word "registration." All revenue is in direct proportion to meter accuracy. It is often amusing to see this basic idea so far lost sight of. When it is a question of pumpage,

filtration, construction, collection, or administration—dollars are spoken of in thousands, and the best is none too good at any price. But when it comes to meters, if a better meter costs two to twenty cents more, more hair is torn out by Commissioners, Engineers and Superintendents than is sartorially safe. If it is remembered that "As your Meters Go—So Goes Your Revenue," the insignificant meter assumes large proportions.

The A.W.W.A. meter specifications, are weaker perhaps from the accuracy angle than from any other. The sections on meter registration are far too lenient. I wish to call attention to a fact too seldom recalled. Water meters can be, and are manufactured down to a percentage of inaccuracy of $\frac{1}{10}$ of 1 per cent instead of 2 per cent, but the evident time and workmanship required will increase the price of such a meter above the prevailing level. We cannot carry this matter far and expect a \$25.00 meter for \$8.00 to \$10.00. However, water meters in the regular price scale are being regularly manufactured today under specifications far more stringent than those of the A.W.W.A. After close study and consistent experimentation it is my belief that for the smaller or $\frac{1}{4}$ gallon per minute flow the specifications should demand a percentage of 95 rather than 90. The better meters today can make, in fact are meeting this requirement. I, personally, would not consider for purchase a $\frac{5}{8}$-inch meter that would not record 95 per cent or better at $\frac{1}{4}$ gallon per minute. If lower prices, and likewise workmanship, are necessary, the classification can be separated and Class "A" meters meet a 95 per cent requirement, and Class "B" meters a 90 per cent figure. Some such definite distinction in classification must be faced for the good of all concerned.

The normal test flows in our present specifications are definite, reasonable, and revealing, but the flows smaller than 1 gallon per minute are the ones that increase revenues.

In experimental tests made on all classes of meters, I have proven that the water meters today, within the standard price range, are or can be so manufactured that flows down to $\frac{1}{12}$ gallon per minute can be registered at 70 per cent or better. Such a tightening up of the specifications would likewise be of distinct advantage to the manufacturer. If clearances were definitely demanded so as to insure greater accuracy on the smaller flows, only that material and workmanship would be employed which attained this end with the least overhead and return after inspection. The cut-throat and chaotic

competition in the field would be minimized, and the purchaser guaranteed better, more accurate meters. It is not to the credit of the association that the manufacturers are years ahead of the present specifications in precision methods, and requirements. The quality of performance of any meter is dependent upon the materials used and the precision with which the parts are manufactured and put together. Certainly our association should specify definitely as to materials and degree of precision.

The present specifications read: "The measuring chamber for all meters shall be made of bronze composition and shall not be cast as part of the outer casing. It shall be machined with great care and secured in position in the outer casing so that any slight distortion of the casing which might take place under 150 pounds working pressure will not affect the sensitiveness of the meter."

"Disc pistons shall be made of vulcanized rubber and shall be fitted accurately but freely in their chambers. Vulcanized rubber pistons shall have a metal reinforcement or a thrust roller."

The heart of any meter is the measuring chamber. The size of this measuring chamber directly determines the speed at which the measuring element must travel to displace a given quantity of water. Disc or piston speeds vary in $\frac{5}{8}$-inch meters from 268 to 356 revolutions per cubic foot of water displaced. Low speed of the displacing unit obvious results in greater life. High speed permits lighter construction and greater accuracy on small streams but cuts down the life of a meter. An ideal combination is the lowest speed possible to obtain extreme accuracy. Yet the present specifications do not set minimum or maximum number of revolutions per cubic foot measured, size of measuring chambers, or weight of measuring element. The accuracy desired depends essentially upon these three factors and they should be outlined specifically.

As far as intermediate gear trains are concerned the same holds true. The function of the train of gears is to translate the revolutions of the disc or piston into a record in cubic feet or gallons. No distinction is made between the old style open train gear, and the oil enclosed train. Reform of our specifications as to intermediate gears is needed. Here again we are far from specific.

The register of any meter completes the reduction begun in the intermediate and indicates the registration. No provision is made for various types of dials, sweep hand, etc., and the metals involved are not specified other than in the words "non-ferrous metals."

One of the essentials in meter maintenance is the interchangeability of parts in the same make of meter. Our specifications today do not mention this detail, in any way, shape, or form. Unless absolute and guaranteed interchangeability is assured, the purchaser is at the mercy of any manufacturer. It is self-evident that an addition to the specifications is needed under this heading. Interchangeability is fundamentally coupled with clearances and so with accuracy. If a meter is accurate, but its parts not interchangeable in every instance, meter repair costs would be ridiculous.

While I have not covered the field as completely as I would like to do, I have cited sufficient evidence, in my opinion, to prove conclusively that our meter specifications of tomorrow should be essentially more definite, complete, and exclusive than those of today. The A.W.W.A. owes it to its members to bring the meter specifications up to date in every detail. It will require study, work, and exhaustive comparisons but it is the only honest, reasonable course to pursue. Waterworks men ask for and deserve specifications that will be protective and progressive, and not so indefinite and inclusive that false security results. I realize that in this discussion I have repeated consistently, but such is needed to drive home the conclusion that specifications of essential meter elements are so involved with each other that the whole and not part makes for a durable, accurate, and reasonably priced meter. I sincerely believe that it is not the privilege but the duty of our Association to make our standard meter specifications of tomorrow as complete and up-to-date as any other specifications in kindred fields. Every cent of our revenue depends on our meters, and our meters should meet adequate specifications.

F. W. E. Weisse. In discussing "meter specifications of today and tomorrow" I can speak only from an operating standpoint. A water meter represents the turning point of the water company's expenses. We have bought bonds and spent money for materials We are spending money continually on the delivery of a commodity to the customer. The time comes when the customer should pay. That amount is indicated by the meter register, and the water meter register standardization is what I would like to discuss.

Men who control the water organization believe that by setting the rate, or making a rate, that they control the cost of their commodity to each customer. In actuality we find that the customer's bill is governed by what the meter reader sees—or imagines he sees.

We have standardized the size of meters. We know that the

measuring device itself has received, and is constantly receiving, the closest attention of the meter manufacturers. It is their business to produce as perfect a measuring device as they can, and we all must admit that they are doing a good job. But there their responsibility seems to cease. They bring a water meter to my desk; they dwell on the perfect fitting disc, or discs; they mention bridges, inserts, thrust rollers, this and the other. They show improvements and standardization on every part of the meter except the most vital thing: the register.

The water meter register of today is the same as it has always been. We find that the most important task, that of determining the amount of the customer's bill, is left to a man who is faced with

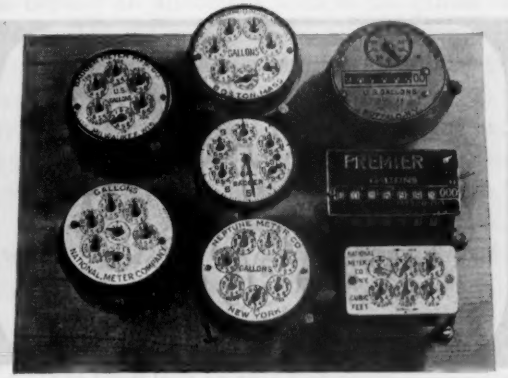

FIG. 1

dozens of different indicating devices. If this man has been reading meters in one locality of a certain manufacturer he must learn all over should he be compelled to read meters in another locality of a different meter manufacturer's product.

Figure 1 shows a few registers picked at random. Notice that not only are the sizes varied, but the type of indication as well. If you will study this picture a minute you realize that there is no intermediate glass between you and the picture. The meter reader, however, in having a so-called frosty or foggy glass cannot as readily determine the starting point, or in other words the lowest selling value pointer circle. Again, on your so-called straight reader you will find that should the register be on a turning point it is practically impossible to determine the proper figure.

Let me digress for a few seconds to explain that this variation, this confusion in our company, having 26,000 water meters, results in more work than 90,000 electric meters require. Electric meter registers are standardized. Let us standardize water meter registers. The same as is the case in electricity, or gas, meters.

In our company the water meter registers are being standardized as shown by figure 2. There you have a unit register, the lowest denominating figure circle on the right, the pointer always travelling clockwise; and it is stated on the register face that one unit represents 100 U. S. gallons.

A. P. KURANZ. The World War ended November 11, 1918 and this was about the same time that the last meter specifications were

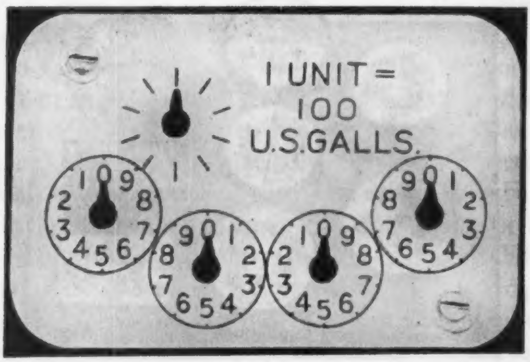

FIG. 2

written. You remember that it was the beginning of air mail. Look at things today. Is the automobile the same? How about the airplane—streamline engines—cars and even streamlined factory machinery? But the water meter specifications are the same as they were in 1918. We must admit, however, that several manufacturers of meters have long ago discarded the old obsolete specification as far as their own manufacturing problems are concerned, but when the subject of "tests" is discussed, we still must go back to the specification which was written at the close of the World War. Certainly it is high time then that something be done about "Meter Specifications" to modernize accepted standards as to accuracy for our present day requirements.

Before we can do much about meter specifications, we must be made conscious of better metering. There are very few water

works plants who do not recognize that metering water is a most equitable manner for both customer and plant. It is not hard to convince the customer today to buy his water through meters because if one were to apply the rates paid on a flat rate basis of so much per faucet, toilet, wash bowl, bath tub etc., which was the common practice fifty years ago, his water bill would be eight to ten times higher than it is at present. The meter was such a great improvement over the flat rate "no meter arrangement" that it was accepted as the last word in the business as far as the revenue was concerned. With the idea of water and air being free, little attention was paid to leaks and losses until such time as we began to realize that water can be misused and through its misuse a source of considerable expense to a community.

Waste has become an abhorrent term in the minds of our people. Since we have recognized and accepted the great improvements the meter has over "no meter" and since we have become mindful of conservation of our natural resources, one of which is water, it follows but naturally to a water works man that the reducing and accounting of the waste and misuse of water is of considerable importance in his system. A water works man may *believe* that he has a very good system and assume that he is getting out of it about all he can. Some assume that if 70 per cent of the water pumped is measured through the customers' meters, this is doing quite well—others say 90 per cent. Water works men generally have been led to assume that much of their loss occurs in main and service leaks and perhaps too much stress has been laid on this feature in accounting for losses. There is no question but what main and service leaks do make up a great percentage of the unaccounted for water and in elimination of waste this part of the system should be checked very carefully. However, it will soon be discovered that there is still quite a volume of loss unaccounted for occurring after such a survey, and there is but one other place to look for it.

The customer's meter must enter the picture and the superintendent finds that during the late years considerable progress has been made by some of the progressive water works men in this field. We are dealing now, of course, largely with the residential meter which is usually from $\frac{5}{8}$-inch to 1-inch in size. From articles appearing in the various water works publications, we are being told that as high as 20 per cent of the water is being lost due to under-registration even on what we might consider a good meter installation.

What has been the actual findings where some of the more progres-

sive water works men have made it their business to get at some of the actual facts? The private water works have lead the way. We can rest assured that these men will always be the leaders since they must depend upon their revenue for sustaining their plant and not upon tax appropriations, and therefore we should be thankful to them that they have shown us the way.

The chart recording device on meters which has come into prominence during the last decade has done much to bring about some very serious thinking on the subject, and it takes but a few examples to make water works men realize that they have been missing a good bet when they have been overlooking the small meter and particularily the small flows on these meters.

If you will put a good testing meter with a chart recording device in several of the residences in your city and at the same time leave the regular meter in its place, you will be convinced that the meter you assumed was registering and recording about 100 per cent of the water passed through it was giving you possibly 75 per cent to 85 per cent or less. You then will begin to see the importance of small flows. The regular residence meter no doubt tested OK on a full flow, intermediate flow and the present minimum flow on the test bench in the shop, but this does not indicate that it is OK for the small flow under actual service conditions.

The last point is the important one. In most houses, you will find the tank type flush toilet; and if you will check, you will find that about $\frac{1}{4}$ to $\frac{1}{3}$ of the water used to fill this tank is not recorded on the meter chiefly because the last 1 to $1\frac{1}{2}$ gallons comes into the tank so slowly that it takes a *good* meter to register and record it. A rate of 2 to 4 gallons per hour is often found in such cases. Many of these tank type valves will not even close at this point and the result is a leaky toilet which may run at the rate of 1 to 2 gallons per hour. It takes a *very good* meter to catch this flow. We have tested installations with the recording chart meter, and the following two cases may be of interest.

We had a $\frac{5}{8}$-inch meter at a residence, and we put our hourly recording chart in front of the house meter; and during 6 hours (from 7:45 a.m. to 1:45 p.m.) the house meter showed 1 gallon used and the recorder showed 6 gallons. No one was home at the time, but we had permission from the people to check as we saw fit. We found the toilet flush tank overflowing constantly and when this was repaired the use stopped. The house meter had been in service for

four months since last tested, and at that time showed a composite accuracy of 97.95 per cent on 20, 10, 6, 4, 2, 1 and $\frac{1}{4}$ g.p.m. with 80 per cent on $\frac{1}{4}$ g.p.m. The meter was removed and tested on $\frac{1}{8}$ g.p.m. (7.5 g.p.h.) and $\frac{1}{16}$ g.p.m. (3.75 g.p.h.) and found recording 20 per cent at $\frac{1}{8}$ g.p.m. (7.5 g.p.h.) and 12 per cent at $\frac{1}{16}$ g.p.m. (3.75 g.p.h.). We were satisfied with the house meter when it was shop tested, repaired and reset 4 months previous. Under these actual service conditions, we were losing approximately $2.40 revenue per year on this service meter.

Another case is very similar. We used the hourly recording chart for 5 days and found 44 per cent under-registration on the home meter. We removed this meter and put in a new $\frac{5}{8}$-inch meter and in one week this meter showed a loss of only 3.4 per cent as compared with the hourly chart recorder. This happened to be an installation which was always paying a minimum bill, so our loss in revenue was not as great as it would have been ordinarily because we had to bring up registration first, but at that our loss was $2.56 per year.

This then brings us to the question before us "What about meter specifications today and tomorrow?" It is our belief that meters should and can be made to register and record the smaller flows much more accurately than the present specification demands. We believe that most manufacturers of meters are improving their standards of manufacture, inspection and testing, and that the specifications on tests could and should be written to include the measuring and recording of smaller streams than is now common practice or a higher percentage than 90 per cent on a $\frac{1}{4}$ g.p.m. flow as well as including other minimum test flows.

It is not the idea of water works men to write a specification on meters that is not practical or demand an article which will cost too much to manufacture or which will not maintain the accuracy on small flows. While we do not feel that we have had enough experience on what the accuracy on small flows could be, the little work we have done does indicate that meters are and can be made which will register 80 per cent of the flow at $\frac{1}{16}$ g.p.m. (3.75 g.p.h.) after they have been in service 60–72 months. We have tested new stock meters before they were put into service, and we find that at $\frac{1}{16}$ g.p.m. (3.75 g.p.h.) we can expect an accuracy of 85 per cent. This would indicate then that meters are and can be made to give us this service and at no additional cost. It may be true that it will necessitate improved machinery in some of the meter manufacturing

companies' plants, and it may have a tendency to increase the price of meters particularly of those in the lower price brackets, but we feel that the first cost of a meter is of less importance since the meter is an instrument made and installed for the sole purpose of measuring the water and recording it accurately. The increase in revenue through such a device will quickly make up the difference in cost between it and some less expensive make.

We should modernize our standards. We, of course, do not urge such a strict specification that meter manufacturers as a group feel they can not comply with it without considerable expense to the water works men in the final cost. We realize that we could specify measuring and recording at very fine flows, but such a device would not be practical and would cost considerable more money than the average water works man would pay and therefore defeat the entire purpose which is to improve the accounting and financial standing of the utility. It is recommended that our Association study this subject very carefully and develop a new set of specifications on meters and their testing.

ABSTRACTS OF WATER WORKS LITERATURE

Key. **29: 408 (Mar. '37) indicates volume 29, page 408, issue dated March 1937. If the publication is paged by issues, 29: 3: 408 (Mar. '37) indicates volume 29, number 3, page 408. Initials following an abstract indicate reproduction, by permission, from periodicals as follows: *B. H.—Bulletin of Hygiene (British); C. A.—Chemical Abstracts; W. P. R.—Water Pollution Research (British).***

LIMNOLOGY

Sunshine and Algae Control. R. F. Goudey. Eng. News-Rec. 120: 581 (Apr. 21, '38). Determining proper time to commence copper sulfate treatment of reservoirs is perplexing problem. Safe limit under certain conditions is entirely too high at other times and organisms frequently get out of control. Observations since '35 on large reservoirs of Los Angeles have shown that abundant microscopic growths coincide with periods of greatest ultra-violet radiation, other factors, i.e., water temp., hrs. of sunshine and mineralization, being below their max. To facilitate these studies, 2 ultra-violet measuring and recording devices were procured with photo-electric cells sensitive to radiations in range 2700–3600 Engstrom units, cathode material of cells being thorium. Daily variation in radiation is 100% plus and minus of av., and hourly variation on minus side is even greater. Equipment has also been obtained to study sun spots. A large sunspot of 100,000 mi. diam. entering lower quadrant usually sets up period of excessive ultra-violet ray radiation. When ultra-violet activity is on increase, copper sulfate or chlorine is applied at lower microscopic counts than heretofore and greater proportion is applied at periods of highest ultra-violet ray activity, i.e., spring and fall. Saving of 20% in chemicals used has been effected and water is of better quality as judged by its freedom from taste and odor.—*R. E. Thompson.*

The Algae of the Margins of Ponds. J. W. G. Lund. Rep. Brit. Ass. Sect. K, p. 434 ('37). Discusses the algal flora of the marginal regions of ponds where vegetable matter is deposited in the autumn. Algae occur as planktonic, epiphytic and bottom-living communities. Motile forms, especially flagellates, are dominant in the bottom-living community, and a seasonal periodicity is shown which can be correlated with the breakdown of the vegetable detritus to form a mud rich in humus. In the deeper regions of the ponds diatoms are dominant. The types of flora in the littoral regions of most ponds and lakes are probably generally of the same nature.—*W. P. R.*

Limnological Study of the Plankton of a Concretion-Forming Marl Lake. M. R. Raymond. Trans. Am. Microscop. Soc. 56: 405 ('37). This study of Bass Lake, in Livingston Co., Mich., is first detailed investigation of typical

marl lake. Not only is bottom completely covered with marl (largely $CaCO_3$) but lake is unique in its immense production of marl concretions. Quantity of plankton is very restricted compared to that of other lakes. Examination of water showed adequate supply of dissolved O for plankton growth. Annual av. free CO_2 content was 2.5 p.p.m. at depth of 20 m. Alky. was due almost entirely to bicarbonates, carbonates in various samples being either small or nil. pH ranged from 7.5 to 8.3. Concentration of electrolytes, 325–350 reciprocal megohms, was greater than that previously reported by others for 530 lakes and lakelets; a condition favorable for plankton growth. Factors whose combined effects are unfavorable for plankton productivity are: the large amt. of marl, scarcity of free CO_2 and paucity of rooted aquatic vegetation.—*R. E. Thompson.*

An Ecological and Taxonomic Investigation of the Littoral Algal Flora of Lake Windermere. M. GODWARD. J. Ecol. **25**: 496 ('37). A detailed account of an investigation of the sessile algae found in the littoral zone of Windermere. The distribution of the algae depends on the substratum (stones, plants, mud, or experimental glass slides) the depth of the water, the nature of the habitat (reed swamps or "inorganic" shores), light and temperature. The effects of these factors are discussed. The periodicity of different types of algae was studied in relation to depth and habitat and was found to be similar in many respects to that which has been established for the planktonic algae. Algae are generally found at their greatest depth at the time of their maximum development. The periodicity of some species is modified by the habitat in which they are growing. The concentration of phosphates, carbonates, nitrates, organic matter and ammonia in the water, and the oxygen absorption of the water were determined in various parts of the lake.—*W. P. R.*

Abnormal Thermal Stratifications of Inland Lakes. (In English). SHINKICH YOSHIMURA. Proc. Imperial Academy (Japan) **13**: 316 (Oct. '37). Abnormal thermal stratifications may occur in inland lakes and be classified as (1) presence of water warmer than 4°C under a surface layer below 4°C particularly under an ice cover; (2) dichothermy with a min. temp. in middle layer, usually established in early spring when although surface layer is warming, middle layer is still cold; (3) mesothermy, with a max. temp. in middle layer, often developed in autumnal partial and complete circulation period when surface layer is cooled by convection; (4) poikilothermy, stratification with one or more min. and max. temp. in middle layer, established on warm days following a cool period. Abnormal thermal stratification is necessarily maintained by the presence of the heavier water of the deep layer, which has greater density due to larger amt. of dissolved substances. 3 kinds of chemical stratifications designated by author—(1) caused by biochemical means, (2) non-biochemical stratification as caused by inflow of underground water of differing chemical comp. into deep layer of lake, (3) combined bio-chemical and non-biochemical means. Table is given in which are listed lakes of world with abnormal stratifications and other conditions for different periods of yr.—Green Lake (N. Y.), Kensico Res., Beasley and Mary lakes being U. S. lakes mentioned. In last 3 of these, principal stratification is of biochemical character.—*Martin E. Flentje.*

The Influence of the Reserves of Readily Hydrolyzable Nitrogen of Mud on the General Character of the Reduction Processes in Various Lakes. S. I. KUZNETSOV. Microbiology (U.S.S.R.) 6: 465 ('37) (English supplement to 6: 201). Mud of 46 lakes was studied. Total N reserves vary from 0.23% in highly mineralized lakes to 4.23% in high-plankton lakes. Study of readily assimilable N (sol. N after hydrolysis of slime with 5% H_2SO_4) indicated that it exceeded 1.19% (dry wt.) regardless of C content, lake had marked O deficit in hypolimnion in summer and in entire mass of water in winter. If it averages 0.27-0.59%, mud decompn. processes are weaker and hypolimnion is well developed, and if less than 0.27% lake is oligotrophic and water is satd. with O almost the yr. around.—*R. E. Thompson.*

Sinking of Decomposing Plankton in Sea Water and Its Relation to Oxygen Consumption and Phosphoric Liberation. H. R. SEIWELL AND GLADYS EDDY SEIWELL. Proc. Am. Phil. Soc. 78: 465 ('38). Study was made of rate of O_2 consumption, P liberation and rate of settling of decompg. plankton. Rate of O_2 consumption per hr. decreases linearly with time. When plankton die, there is rapid liberation of P within 24 hrs., then rate drops off quite rapidly. "Equiv. radius" of decompg. org. matter is estd. by special modifications of Stokes' law.—*R. E. Thompson.*

Fighting Cooling Pond Algae. ELTON STERRETT. Power Plant Eng. 42: 175 (Mar. '38). Copper sulfate necessary for control of algae in cooling pond was reduced 60% by heating the treating solution before application at the surface thereby reducing thermic circulation and maintaining the bulk of the reagent in the vital zone.—*T. E. Larson.*

Chlorine Gas to Control Cooling-Tower Algae. T. C. WALLACE. Gas, 8: 32, 34 ('37); Gas Age, 80: 37 ('37). Difficulty due to algae formation in cooling water of gas compressor plant was eliminated by introduction of up to 10 p.p.m. chlorine every 7 days. Cooling tower is of open type and contains about 50,000 gal. of water circulating at rate of 3,000 g.p.m. Chlorine was introduced through laboratory flow meter at rate of 12.5 lbs. per min. Higher rates will be tested. No corrosion was observed and all trace of chlorine disappeared from water about 1 hr. after application was discontinued.—*R. E. Thompson.*

A Fungus in Acid Copper-Plating Baths. NANDOR PORGES. Metal Ind. (N. Y.) 36: 19 ('38). Fungus, identity of which is not known, is reported which grows and produces jellyfish-like colonies in soln. contg. $CuSO_4$ to satn. and 6.8% H_2SO_4.—*R. E. Thompson.*

TASTE AND ODOR CONTROL

Present Status of Taste and Odor Control in the Waterworks Field. NORMAN J. HOWARD. Eng. Cont. Rec. 51: 12: 25 (Mar. 23, '38). Methods of taste and odor control and their effectiveness under various conditions are reviewed. Filtration through granular activated carbon being increasingly advocated. There is definite relationship between pH value and taste and

odor production: susceptibility to taste increases above pH 7.0. The method of disposal and treatment of industrial wastes is important, e.g., whether discharged into municipal sewers, etc.; the activated sludge process of sewage treatment, when efficiently operated, invariably produces an effluent which will not later cause taste and odors when discharged into bodies of water used for water supply. When copper sulfate is used to control algal growths, activated carbon may be necessary to eliminate secondary odors. Equal parts (0.3 p.p.m. of each) of copper sulfate, ammonia and chlorine (termed cuprichloramine) has been found effective in combating algae. Anhydrous ammonia gave better results than ammonium salts.—*R. E. Thompson.*

Comparative Effectiveness of Taste and Odor Control Treatments. George B. Prindle. Eng. Cont. Rec. 51: 3: 14 (Jan. 19, '38). Author summarizes, with reservations, the value of various methods of control. Aeration is of very limited value in removal of odors of organic origin. Superchlorination of raw water followed by dechlorination of filtered water is only effective with relatively low odor intensities. Prechlorination may at times seriously interfere with odor removal processes. Chloramines in the raw water are less likely to interfere with taste control than free chlorine. Carbon will remove any odor, provided sufficient can be added. It should be applied either before or immediately after the water enters the mixing basin. Carbon appears to improve coagulation with alum if added at approx. the same point as the alum. Plant-scale experiments showed a marked interference with coagulation when carbon was added 15 min. before or after the alum. Carbon may be introduced as a suspension in the alum solution without affecting its activity. This is true even when the carbon remains 24 hr. or more in the solution tank.—*R. E. Thompson.*

How to Determine the Effectiveness of Activated Carbon for the Control of Tastes and Odors. Henry Laughlin. Eng. Cont. Rec. 51: 12: 31 (Mar. 23, '38). Factors influencing the effectiveness of powdered activated carbon include: (I) adsorptive capacity, (II) ability to disperse and (III) suspendibility. (I) can be evaluated by determining the phenol value, i.e., the amount of carbon required to reduce the phenol content of a solution containing 0.1 p.p.m. to 0.01 p.p.m. Carbon with a phenol value of 20 p.p.m. is now being produced. (II) may be determined by observing a suspension of 200 p.p.m. in a Burgess-Parr turbidimeter. (III) can be estimated by allowing 8 liters or more of a suspension of 20 p.p.m. of carbon to settle for a predetermined period based on plant practice, siphoning off the top 7 liters and measuring the carbon in the settled portion by filtering through a Gooch crucible, drying and weighing. Apparent density is intimately related to (II) and (III). Carbon with an apparent density of 325 grams per liter gives excellent results in plant practice.—*R. E. Thompson.*

Activated Carbon. E. A. Sigworth. J. N. E. W. W. A., 51: 200; (Jun. '37). Activated carbon in powdered form first used in '30, plants using material increased to 14 during that year and to over 800 at present. Resumé of advantages of use is given. In 96 plants, 61 fed carbon prior to sedimentation,

27 after and 8 by split treatment. Dosage varies from few pounds to as high as 200 lbs. per mil. gal., av. approx. 16 lbs. per mil. gal.—*Martin E. Flentje.*

WATER QUALITY AND TREATMENT

A Year Book of Water Chemistry and Purification. Vom Wasser (Ger.) Vol. XI ('36) 293 pp. *Experiments with Activated Carbon.* A. PETER. p. 68. Account of three years experiments using powdered and granulated activated carbon ("Hydraffin") in slow and in rapid filters, high color of peat water and organic matter being effectively reduced. Experiments in which water was treated with 10–20 p.p.m. chlorine with subsequent dechlorination by activated carbon are described. *Economies Effected by Use of Soft Water.* E. NAUMANN. p. 187. In estimation of amount of soap to be saved by softening a public supply only that proportion of water in which soap is actually dissolved should be considered. Only about 20% of water used in domestic supply affects soap usage. Proportion of supply used in industry varies greatly, it is calculated as 44% in Essen and 16% in Frankfurt. Statistics show that 17% of German water supplies have hardness over 20 degrees (German). Figures of Hudson giving ratio of soap consumption to hardness for four American towns are discussed. (See also abstract in J. A. W. W. A. 30: 178 (Jan. '38)). *Pipe Protection in Soil.* C. M. WICHERS. p. 194. Two methods of combating corrosion are discussed, (1) improvement of soil surrounding pipes by neutralizing with lime, or replacement of corrosive soil surrounding pipes by clay, and (2) protection of pipes by dip coating of asphalt, with jute covering or cement coating. *Effect of Sulphite Cellulose Waste Waters on Clarification of River Waters.* J. MILBAUER. p. 214. Electrophotometric sedimentometer is described which permits observations on effect of sulphite wastes on settlement of aluminum hydroxide. *Spectrum Analysis in Water Chemistry.* K. PFEILSTICKER. p. 238. Author quotes use of spectrum analysis for water in United States (Braidech and Emery, J. A. W. W. A., 27: 557 (May '35)). In Germany waters of Neckar and tributaries have been investigated spectroscopically to determine effect of effluents and results are given for lead, chromium, zinc, iron, manganese, sodium, potassium and boron. Spectrum analysis is rapid, simple and sensitive, it is suitable for testing resistance to corrosion and to determine origin of polluting substances. *Scale Buoys.* A. SPLITTGERBER. p. 266. Scale buoys or "Tonisators" are glass vessels containing mercury in atmosphere of rare inert gases, especially neon. It is claimed that they act on water by electrical energy. No change in water is shown by analysis, but in some instances boiler scale appears to have been more easily removed by their use. Author considers that although scale buoys have some action on water they are of no real importance in boiler operation since hardness substances are not removed. *The Composition of Universal Indicators.* L. W. HAASE. p. 276. Gives composition of four universal indicators for pH measurement, containing several individual indicators. Included are Kolthoff's and also Emil Bogen's.—*W. G. Carey.*

The New Water Works at Ludwigshaven on Rhine. FRITZ SCHAAFF. Gas- u. Wasser. 81: 162 ('38). The analyses of the raw and filtered water are given

and the equipment is briefly described. Observation tubes 5″ internal diam. and 5′ long, with glass covers on each end are provided at inlet and outlet of filters to give some idea as to the internal condition of the mains. Heavy deposits form on the raw water side and only slight deposits on the filtered water (freed from Fe and Mn). When any well gives unduly high amts. of algae, the resistance of the filters increases quickly, so that they must be washed more frequently. When this happens the well responsible for this condition is switched out. Corrosion difficulties in the interior of the iron filter chambers were eliminated by the use of a bituminous-base paint.—*C. A.*

Reconstruction of the Cairo (Ill.) Water Purification Plants. C. M. Roos. Bul. Assoc. State Eng. Soc. 13: 2: 93 (Apr. '38). The first water purification plant was constructed in Cairo in 1900. In '13 equipment for use of calcium hypochlorite and a bacteriological laboratory were installed. In '37 a new plant was constructed with 8 rapid sand filter units, each having capacity of 0.5 m.g.d. The plant includes two circular, welded-steel sedimentation tanks with combined capacity of 700,000 gal., and a 50,000 gal. elevated steel wash water tank. The filters are constructed in circular steel tanks, 15′ dia. and of otherwise convential design. L. R. Howson, in discussion, points out two novel features: (1) the spiral, steel baffles in the sedimentation basin, and (2) the use of circular wash water troughs.—*H. E. Babbitt.*

Looking at Today's Problems. Paul Hansen. Eng. News-Rec. 120: 566 (Apr. 21, '38). Developments in water purification are reviewed. There are now 2,120 municipal filtration plants in operation, of which only 17 are of slow sand type, combined nominal capacity being 7500 m.g.d. In '37, 141 installations with total capacity of 204 m.g.d. were completed. In addition, 125 installations for sterilization only were placed in operation. Major improvements have been made in regard to dry feeding of chemicals, including wider use of measurement by weight and employment of large dissolving boxes equipped with stirrers. Activated carbon is being more extensively applied and dosages higher than 500 lb. per mil. gal. are being employed for short periods. An elusive remnant exists of what appears to be water-borne intestinal disturbances. The more serious outbreaks are related to cross-connections and no doubt some are attributable to inadequate purification, especially at smaller plants. Marked variations in mineral content are suspected of responsibility for some of mild forms of intestinal disturbances: this may explain some of physiological effects attributed to flood waters. Automatic control is being developed in many phases of operation and surface washing of filters is being widely accepted.—*R. E. Thompson.*

Trends and Developments in Water Purification Practice in 1937. Harold E. Babbitt. Bul. Assoc. State Eng. Soc. 13: 2; 102 (Apr. '38). Trend has been toward refinement in conditioning of water before treatment, reduction of hardness, and the neutralization of corrosive aggressiveness. Among devices which have been changed and improved are: mechanical aërators, chemical mixing and agitating equipment, basin agitating equipment, CO_2 generating equipment, under-drain systems for rapid sand filters, elimination of gravel

from filters, automatic control of gravity filters, and new synthetic zeolites for water softening. In operation the methods of coagulation have been improved and new chemicals introduced. Coarser filtering medium is being used for rapid filters, together with porous underdrains, and surface wash. Colorimetric and spectrum methods of analysis have been introduced to expedite laboratory procedure, together with photometric devices and methods for laboratory procedure and plant control. The potassium palmitate test for hardness has received attention and methods for overcoming the recognized difficulties with the orthotolidine test for free chlorine have been suggested. More able personnel is required for the control of water purification plants.—*H. E. Babbitt.*

Forecasting the Next Decade in California Water Treatment Practice. CARL WILSON. W. Cons. News **12**: 379 (Oct. '37). Recourse to artificial improvement of water quality is steadily increasing in Calif., particularly in the southern half of state. Many new softening plants expected and next decade expected to show progress in movement eventually leaving no surface water supply of importance not filtered and treated for taste and odor control. Author expects electric eye to assume important place in purification and suggests photo-electric recording turbidimeters with possibility of automatic washing of filters when turbidity exceeding set limit is passed. Further development of clarifier to give 0 turb. water, universal use of pH correction, rapid spread of use of activated carbon are among other looked for happenings. Carbon may be used less as a floc conditioner or for stabilization of sludge for which other and better means are available. Next decade will see increased use of $CuSO_4$ and chlorine for algae control with improved methods of application, of which boat built by Rice, Gandey's dry feed machine and water carried method of Arnold are examples. Weeds and marginal growths will be more generally controlled to give improvement in taste and odor. Universities may be expected to give specialized courses covering scientific needs of purification man. Suggests possibility of formation of National Institute of Water Technology for research and study of water problems.—*Martin E. Flentje.*

Suitability of Colorado River Water for Citrus in South Coastal Basin. W. P. KELLEY. Calif. Citrograph, **22**: 235, 272 ('37). Weighted mean composition of Colorado River water, based on weekly samples taken over period of 10 yrs. at the Grand Canyon, is bicarbonate 172, chloride 62, sulfate 230, calcium 76, magnesium 24, sodium 82 and boron 0.15 p.p.m. It appears that use of this water for irrigation in the metropolitan water district will not seriously affect growth of citrus trees, the underground water supply or the physical condition of soils in South Coastal Basin.—*R. E. Thompson.*

The Salt (Sodium Chloride) Content of Rain Water. L. J. H. TEAKLE. J. Dept. Agr. W. Australia **14**: 115 ('37). During the period '33–'36 the NaCl content of rain water collected in the gages at the Merredin research station, Western Australia, averaged 7.0 p.p.m., while that collected at the Salmon Gums station averaged 9.4 p.p.m. The figures include the NaCl that may

have been present in dust deposited in the gages. In general, the NaCl content of the water decreased with increase in the monthly pptn. The max. deposition of NaCl appeared to occur in the winter months, June, July and Aug., at both stations and the min. in Feb.—*C. A.*

Studies on the Removal of Fluorine from Drinking Waters in the State of Iowa. C. A. KEMPF, W. E. GALLIGAN, D. A. GREENWOOD AND V. A. NELSON. Proc. Iowa Acad. Sci. **43**: 191 ('36). F can be removed from drinking water by treatment with $Al_2(SO_4)_3$. The floride concn. has been lowered by such treatment to 1.5 to 2 p.p.m. of water from an original concn. of 7 to 10 p.p.m. Acidity of the water is a factor in the removal of the F by $Al_2(SO_4)_3$. This is in part due to the nature of the floc produced under different H-ion concns. These expts. were performed on water fed into the plant with a velocity as high as 1 g.p.m. Before large amts. of water can be treated successfully and on a practical basis other factors are still to be studied in order to obtain a suitable potable water.—*C. A.*

Mineral Waters Containing Iodine in the Region of Archangel. A. A. SKROBOV. Rasvedka nedr. **12**: 26 ('37); Chem. Zbl. **1**: 959 ('38). The iodine contents of waters from 32 wells in the region of Archangel were found to vary between 0.7 and 23.7 mg. per liter.—*W. P. R.*

Bromine and Iodine Content of Water from the Kuibischev Region Oil-wells. N. D. SMIRNOV. J. Industr. chim., Moscou. **14**: 1222 ('37); Brit. chem. Abstr. A., I, p. 636 (Dec. '37). The petroliferous water from the oil wells of the Kuibischev region contains 12.5-650 mg. of bromine and 0.3-7.5 mg. of iodine per liter. Analyses of water from several borings are given.—*W. P. R.*

Chemical Water Analyses and Their Interpretation. A. T. BYRAM. Eng. Cont. Rec. **51**: 12:42 (Mar. 23, '38). The source and significance of hardness, calcium, magnesium, iron, aluminum and chlorides in water are discussed and the amounts of these constituents in representative Ontario water supplies are presented in tables. An iron content higher than 0.3 p.p.m. is undesirable, as is also magnesium in excess of 100 p.p.m. The greatest objection to chlorides is the taste, which becomes noticeable at about 300 p.p.m.—*R. E. Thompson.*

Notes on the Examination of Water Supplies and Sources. K. E. HIGHAM. Surveyor (Br.) **93**: 323 (Feb. 25, '38). Purity of water supply is a major factor in health of a community. A standard of purity should be established. No acceptable definition of the legal requirement of "pure and wholesome water" has been offered. Sir A. Houston defined it as water "in such a condition that it cannot cause typhoid fever, chlorea, or other water-borne disease. It must be free from chemical poisons and have no injurious effects on metals. It should be bright, clear and sparkling, free from suspended matter, reasonably soft and the salts in solution should not be present in excessive amount." No legal standard of purity has been prescribed. All samples of water must be carefully taken and certain major points concerning sampling are described.

Scope of the analysis depends in part, on information gained from a preliminary examination of the source. The scope of chemical, physical, microscopic, and bacteriological analyses is described.—*H. E. Babbitt.*

First Report on Methods of Examination and Disinfection of Water for Troops on Campaign. W. J. BABECKI. Rev. intern. Croix-Rouge **19**: 1021 ('37). A comprehensive discussion of the chem. and bacteriol. impurities that may be encountered in water by armies in the field. Probable contamination of water supplied by chem. warfare agents and other poisons is described. Analytical procedures and purification methods are given.—*C. A.*

Water Purification in Garrison and Field. THOMAS P. BROWNE, II. Military Engr. **29**: 437 ('37). Discussion of impurities in natural water, criteria of a good supply and methods of purification. Screening clarification, settling, aeration, filtration, Fe and Mn removal, softening, sterilization, O removal and neutralization, together with equipment for these processes, are described. —*R. E. Thompson.*

CLARIFICATION AND FILTRATION

Rate of Sedimentation of Flocculated Particles. C. B. EGOLF AND W. L. McCABE. Trans. Amer. Inst. Chem. Eng. **33**: 4:620 (Dec. '37). The sedimentation of flocculated particles was studied using five different materials, (a) silica particles 16 mu in radius, (b) silica particles 5 mu in radius, (c) lead chromate, (d) zinc oxide and (e) ferric oxide. The temperatures varied from 20° to 40°C., and the initial heights of the suspensions from 12.5 to 61.7 cm. The concentrations varied from the point where the suspension no longer settled with a sharp line up to the point where free settling was no longer exhibited. A method of reconstructing the curves is proposed which divides the process into the initial straight line or free settling period and the final or compression period. The general accuracy of the reconstruction is ±20% in 80% of the cases.—*O. M. Smith.*

The Mechanism of the Clarification of Muddy Water by Strychnos Potatorum Seeds. K. SUBBARAMIAH AND B. S. RAO. Proc. Indian Acad. Sci. **6**: 59 ('37). The clarifying action of an aqueous paste of the seeds of *Strychnos potatorum* was studied, using a 1% aqueous suspension of kaolin from which the coarse particles had been removed by sedimentation. The paste had a pH value of 6.8-6.9. Action was compared with that of strychnine hydrochloride, egg albumen and their mixtures, and barium chloride. Clarification is due to the combined action of colloids and brucine in the seeds; the alkaloid ions coagulate the suspension after it has been sensitised by the albumen and other colloids. The best results are obtained with 0.003% of seed material; if more is present coagulation is prevented by the stabilization of the suspension by the excess colloids. Experiments with albumen in the presence of strychnine hydrochloride or barium chloride confirmed this view. A 0.05% suspension of arsenic trisulphide treated with the seed paste gave results similar to those given by the kaolin suspension.—*W. P. R.*

A Precise Method for Sieving Analyses. M. WEBER, JR. AND RAYMOND F. MORAN. Ind. Eng. Chem., Anal. Ed., **10**: 180 (Apr. '38). Testing sieves commercially available, even though conforming to A.S.T.M. specifications, cannot be trusted to give accurate results without calibration. Sieving analyses on standard samples are generally unsatisfactory. Determination of effective opening of plain-weave sieves was made by examination with microscope equipped with calibrated ocular micrometer. Measurements were made on representative groups of five adjacent individual openings along two diameters of sieve parallel to warp and shoot respectively. On sieves coarser than No. 200 a total of 100 measurements gave results reproducible within 1%; 200 measurements were needed for finer sieves. In 33 sieves examined in sizes 18 to 325, no individual openings fell outside A.S.T.M. tolerances, but in five sieves dispersion of size of opening exceeded A.S.T.M. tolerances. As dispersion increases sieve behaves as if average openings were somewhat greater than observed. This effect increases with time of sieving and must be corrected by empirical formula. Technic of test sieving must be standardized for each type and size of product. Mechanical sieve shaker should be used, number of sieves and their sizes must be carefully selected and sample size and time of shaking must be balanced against each other. Further work is needed on calibration of twill-weave sieves and to check applicability to materials other than the crystalline soda ash and sodium bicarbonate used in checking results of microscopic examination.—*Selma Gottlieb.*

Some Points on Water Works Design from the Operator's Viewpoint. W. M. OLSON. Bul. Assoc. State Eng. Soc. **13**: 2:98 (Apr. '38). Desirable items to be provided in design of filters and pumping station include: an intake free from ice; an unfailing source of power; accessible location of pumps; readable location of gages and meters; proper facilities for handling and feeding chemicals, with particular attention to dry feed, liquid ammonia, and liquid chlorine equipment; flexibility in mechanical mixing devices and, if possible, the provision of diffused air for mixing; provision for the washing of settling basins; devices for washing filters that will avoid mud balls; lighting of filters that will permit observation of all parts of the filter; adequate baffling in filtered water basin to permit suitable period of contact for chlorine or ammonia; high pressure water for operation of hydraulic equipment; adequate elevated water storage; proper indicating and safety devices on electrical equipment; adequate illuminating circuits and illumination to prevent glare; emergency lighting equipment; adequate valves; heating devices for the building to be in duplicate; paint for service as well as appearance; window screens; a spring-wound clock; locker room with shower; and a centrally located operating booth equipped with recording gages. It is easier to eliminate a superfluous device than to install a needed one overlooked in the design.—*H. E. Babbitt.*

Water Works Plant and Fittings. ANON. Suveyor (Br.) **93**: 199 (Jan. 28, '38). Prominent among new developments in metering and gaging apparatus is the "Multelec", an electrical device, applicable to automatic recording of pH, turbidity, salinity, and acidity. Special attention has also been given to

gages for assuring constant rates of filtration and to accurate gaging of stream flow. An inexpensive water-level recorder, known as the L2 type, has been used with success. The year '37 has shown a further remarkable increase in the use of such familiar meters as the Kent Venturi for bulk measurement and the M2 positive meter for distributed supplies. There has been a considerable extension of the employment of automatic control systems to govern operation of pumping plants. A number of installations of heavy-oil engines for driving pumps is recorded, and the use of improved chlorine-control equipment.—*H. E. Babbitt.*

The Magno-process for the Treatment of Industrial Waters. AUG. F. MEYER. Zellstoff u. Papier **18**: 201 ('38). A description of the method of prepn. and use of the "Magno-mass" for water clarification; a mixt. of MgO and $CaCO_3$, obtained by carefully calcining a special dolomitic limestone, was used as the filtering medium. This Magno material efficiently removes the free CO_2, Fe and Mn from the water and coats inner surfaces of pipes and vessels with a rust-preventing lime coating. These properties make this filtering process particularly suitable for pulp and paper mills.—*C. A.*

HEALTH AND HYGIENE

Milwaukee Water Blamed for Gastro-Enteritis. ANON. Eng. News-Rec. **120**: 701 (May 19, '38). In report completed May 5, outbreak of gastroenteritis in Milwaukee area in Feb. 1938 was attributed by Wisconsin Bd. of Health to pollution of city's water supply. Finding was based on fact that pollution of raw water was observed at time of outbreak, that about 27,000 people were affected nearly simultaneously, that incidence was largely confined to area using Milwaukee supply and that persons contracting disease outside that area had recently visited city. "No negligence," report states, "can be attributed to health or waterworks authorities . . . . since chlorine residual appeared ample at all times and B. coli index of tap water was well below accepted . . . . standards. It appeared that water treatment facilities available in city at time were inadequate for purification of water for emergency of character experienced during outbreak." Disagreement with the state's conclusions was expressed by J. P. Koehler, Milwaukee Health Commissioner, finding that epidemic was probably spread like colds, by personal contact, air contamination and contamination of pools and ditches, etc. He does not believe that water supply can be blamed. City council is considering requesting U. S. Public Health Service to decide between the two opposite viewpoints.—*R. E. Thompson.*

Epidemic is Blamed on Water Supply. ANON. Eng. News-Rec. **120**: 286 (Feb. 24, '38). The 1935 epidemic of typhoid fever in Minneapolis, which included 175 cases between May 4 and Aug. 10, is attributed to maintenance of insufficient chlorine residual during period of high pollution of raw water in report presented to city council by state dept. of health. Outbreak began less than month after residual chlorine in city water had dropped below 0.1 p.p.m. and ended about a month after residual chlorine was increased to 0.3

and 0.5 p.p.m. Report states that experiments have shown that recently isolated typhoid bacilli may survive for 18 hrs. or longer in presence of chlorine concentration equal to that in the distributed water at time of epidemic. Report also indicated that there is considerable no. of physical defects in in pumping station, purification plant and distribution system and in plumbing systems both privately and publically owned. To avoid danger in future, dept. recommends changes in certain physical features of supply and improvements in administration, particularly the appointment of a "qualified public health engr." in the office of the commissioner of health to devote his full time to solution of problems concerning the water supply.—*R. E. Thompson.*

Cross-Connections in Water Supplies. RENE CYR. Can. Pub. Health J. **29:** 131 (Mar. '38). Seven outbreaks of typhoid and dysentery in Quebec which were traced to cross-connections between municipal or institutional supplies and industrial or fire protection systems, or to use of auxiliary intakes, are described. In one section of Montreal, typhoid incidence was much greater than in city as a whole. Survey disclosed cross-connections. As result of investigations and recommendations made following these outbreaks, the Quebec Public Health Act was amended as follows in Apr. '33: "No connection may be made between the public water distributing conduits and the distributing conduits of a private system until the plans and specifications have been submitted to the Director of the Provincial Bureau of Health and his approval has been obtained. Plans and specification of existing connections must be submitted to the Director of the Provincial Bureau of Health before Jan. '34. Such connections must be done away with or altered whenever, in the Director's opinion, they constitute a menace to public health."—*R. E. Thompson.*

Cross Connection Crimes. JOEL I. CONNOLLY. Eng. News-Rec. **120:** 575 (Apr. 21, '38). Examples of cross-connections in distribution systems are described and discussed. Air conditioning has added to cross-connection hazards in (1) direct sewer connections, (2) back pressure from circulating pumps, and (3) make-up water inlets submerged in air-washer pans. The Chicago amebic dysentery outbreak was caused, in part, by contamination through condenser of ice machine used for air conditioning. During past 4 yrs., 589 direct ice machine condenser cross-connections to sewers have been found and removed in Chicago, many of them in counter freezers in stores. Pressure records for upper floors of bldgs. in large cities have shown that it is not uncommon for water pressure to drop to that of atmosphere or below. In one large new office bldg., plumbing of which was thoroughly inspected at time of erection and found satisfactory, complaints of diarrhea were received and investigation revealed recently installed cyanide tank with submerged inlet in a silver plating establishment. This demonstrates futility of inspection alone. Much can be accomplished through education of engrs., architects, plumbers and property owners, supplemented by inspections, plan examinations and identification of piping by distinctive colors. Where house pressure is raised above city pressure, it may be advisable to limit to bldg. any pollution which may occur by physically separating house system from mains by use of surge tank.—*R. E. Thompson.*

Dysentery in Great Britain.—Prevalence of Dysentery. Lancet (British). Dec. 18, '37. pp. 1437; 1462. The Registrar General's returns show an increase in the notifications of dysentery since '35 with a greatly enhanced incidence in the autumn of '37, dating from the 35th week. The higher levels of '35 and '36 compared with those of previous years are made still more apparent when the figures for the public mental hospitals (given in the annual reports of the Board of Control) are deducted from the totals. The remaining figures for '35 and '36 are respectively double and treble that for '34 and it is not unlikely that the figure for '37 will be tenfold. The same tendency to increase appears to be true of many European countries. Increased interest in the disease and a correspondingly improved standard of diagnosis may be a partial factor, but is unlikely to be the whole explanation. It may safely be said that infection with the Sonne bacillus is endemic in Great Britain and with the growing popularity of foreign travel importation of the presumably more toxic continental strains must steadily increase. Although infant cases still predominate there seems to have been a change in both place and age distribution as well as increased prevalence. There is a need for early bacteriological stool examination to bring cases quickly under the necessary control and by virtue of more accurate notification give a better picture of the real prevalence of the less well-known types of bacillary dysentery in this country.—*B. H.*

Typhoid in Our Generation. Lancet (British). Dec. 4, '37. p. 1340. It is pointed out that the extremely low level of mortality from typhoid fever which characterizes our generation—a rate much less than one-tenth of the rate prevailing a generation ago—is compatible with a quite extensive prevalence. In the ten years '27–'36, nearly 25,000 cases were notified in England and Wales and 2,821 deaths were registered. From about 3,500 cases in '27 there was a fall to only 1,200 in '34 and then a rise. Relatively to the population at risk, the incidence, and mortality, have been slightly higher in small towns than elsewhere and lowest in the large urban aggregates. Localized epidemics, of course, greatly influence the totals. Thus in '32 the Urban District of Malton contributed 249 cases and only two in the four following years.—*B. H.*

Incubation Period of Typhoid. M. Greenwood, W. W. C. Topley, Marion Watson and Joyce Wilson. Lancet (Br.) p. 1399 (Dec. 11, '37). These authors state that it is not uncommonly assumed that in human epidemics in which a large number of persons are exposed to risk of enteric infection from polluted water or milk during a few consecutive days, and the risk is removed by appropriate measures, apart from contact infections, cases should cease to occur within some fixed period. Their experience with experimental *Bact. typhi-murium* infections of mice lead them to suspect that this assumption is ill-founded, as when 440 mice were infected and subsequently isolated separately the majority of deaths occurred between the 7th. and 14th. days with a modal frequency on the 10th. and 11th. days. But the curve of mortality was markedly skew and some mice were still dying 25 days or more after infection. While not regarding the form of the curve as an adequate reflection of variations in the incubation period, they think that some part is due to variations in

incubation time. From this they argue that it is probable the same may be true of typhoid in man, and apart altogether from contact infections, a few cases may be expected to occur well after the time limit calculated on the basis of the customary incubation period. In support of their contention they quote a water-borne epidemic in which 21 persons were infected on one day. In these the mean incubation period was 13.8 days, but in one case it was as long as 29 days. A second point they raise concerns the possibility of contact infection from carriers, or from missed cases. In the mouse epidemic already mentioned they found that of 140 mice in apparent health killed on the 28th. day, *Bact. typhi-murium* was isolated from the spleens of 70. They would expect on this analogy, therefore, to find in large human water- or milk-borne epidemics that latent infections would be relatively common and that these would lead to a certain number of contact infections not traceable to any preceding case. This number would depend on the extent to which sufferers from these latent infections were concerned in the preparation or handling of food.—*B. H.*

Fluorine in Food Products. H. C. LOCKWOOD. Analyst (Br.) **62**: 775 ('37). A number of common foodstuffs were examined for their F content, using a modification of the distillation technique employed by Willard and his collaborators. The procedure is based on the method originated by De Boer who found that a mixture of solutions of zirconium nitrate and alizarin sulfonic acid in the presence of HCl was capable of detecting 0.001 mg. of F in 1 ml. of water. No foodstuffs examined, with the exception of tea, contained more than 2 p.p.m. F. Results were of the following order: nil in biscuit flour, gelatine and tinned pineapple; 1 p.p.m. in white bread, potato and honey; 2 p.p.m. in beef, egg yolk and ginger biscuits. A number of chemical substances which may be used in connection with foodstuffs were also examined and values such as 6 p.p.m. for sodium chloride and 1 p.p.m. for sodium bicarbonate were obtained. The author suggests that whilst it is generally recognized that F in excess of 1.5 p.p.m. in water may have deleterious effects on health, foodstuffs may contain appreciably more than this before they should be regarded as unfit for consumption. Less than 0.1 p.p.m. of F was found in the Birmingham water, which comes from the Elan Valley. In confirmation of an observation first made by Reid, the author finds that tea contains comparatively large amounts of F. Values of 40–47 p.p.m. for China tea and 60–70 p.p.m. for Indian tea were found and simple infusions after 5 min. contained 75% of the total F. In the case of solid foodstuffs the author criticizes the values given by Reid, who used Boruff and Abbott's titrimetric technique.—*B. H.*

Cryolite Spray Residues and Human Health. S. MARCOVITCH, G. A. SHUEY AND W. W. STANLEY. Tenn. Agr. Expt. Sta., Bull. No. **162**: 3 ('37). White rats were used to evaluate toxicity of fluorine compds.; daily dose of 0.4 mg. of F per kg. body wt., or 4 p.p.m. in total diet, will not produce tooth striations. White rats are about as susceptible to F compds. as men. A child weighing 30 lb. requires about 6 mg. of F daily to produce mild case of mottled teeth. One p.p.m. dissolved F in water supply is at least 10 times as toxic as relatively

insol. powd. form occurring as spray residue. This is due in part to fact that water used in cooking concentrates the F. From 1 to 12 p.p.m. of F is consumed daily by Americans. Studies show that present U. S. tolerance of 0.01 grain per lb. of foodstuffs, or 1.4 p.p.m., is not based on fact, but applied arbitrarily, and should be raised. Eighty-one references.—*R. E. Thompson.*

Influence of Calcium in Cooking Water upon Mineral Content of Vegetables. ISABEL NOBLE AND EVELYN G. HALLIDAY. Food Research **2**: 499 ('37). Vegetables cooked in liquids of different Ca concns. contained more Ca than when cooked in distd. water and, with exception of carrots, more than when raw. They suffered approx. equal losses of phosphorus during cooking. Thus, vegetables cooked in hard water, or in water contg. added Ca, become richer in this element. Green beans, asparagus, spinach leaves, peas and carrots were used in the expts.—*R. E. Thompson.*

Arsenical Poisoning of a Large Family. JACQUES ARCHAMBAULT. Can. Pub. Health J. **29**: 67 (Feb. '38). During investigation of arsenical poisoning of 9 members of a family in a Quebec town, which was traced to use of a bread powder containing arsenic, a trace of arsenic was found in a neighboring outcrop of rock and in water of nearby spring. Arsenic was not detected in well water used but the scale in kettle employed for boiling the water contained 7.5 p.p.m. As_2O_3.—*R. E. Thompson.*

Chronic Arsenic Poisoning. ROGELIO E. TRELLES. Bol. obras sanit. nación (Buenos Aires) **1**: 448 ('37). In certain regions of Cordoba province the water contains large proportions of As and Vanadium. Numerous cases of chronic As poisoning have been found to be due to use of these waters.—*R. E. Thompson.*

RESERVOIR AND STREAM POLLUTION

Meeting the Demand for Recreation Facilities Near Public Water Supplies. DAVID E. MOULTON. J.N.E.W.W.A. **51**: 370 (Dec. '37). Article describes development of recreational grounds near Portland, Me., water source, Sebago Lake, undertaken to provide camping and other facilities for roving travelers who at times trespass on protected section of watershed. Sebago L. and tributaries constitute unique water supply because of size, water quality, etc. Water surface of lake is approx. 46 sq. mi., in many places depth is over 300′, and cap. is sufficient to furnish the 400 m.g.d. daily run-off of Presumpscot R. (outlet of lake) for 8 yrs. before emptying lake, even if there were no replenishment. Supply purchased by Water District in '07. At present time 98% of shore line within 2 mi. of intake is owned and controlled by District. The recreational grounds intended to draw campers and rovers from watershed area are around ponds known as Otter Ponds. $44,000 expended for labor and materials so far—providing fire places, ball park, beaches, etc. Considerable success has already been achieved in keeping people off watershed even before official opening of park.—*Martin E. Flentje.*

The Effect Upon Fish of Rain Washings from Tarred Roads. C. H. Roberts. Rep. Brit. Ass. Sect. D. P. 363. ('37). Discusses the effects of washings from tar, bitumen and cement roads on streams. Dust may smother water weeds, organic matter in the washings decomposes and has an effect similar to that of sewage, and lubricating oil affects small organisms such as insects. Washings from ordinary tar roads contain poisonous substances such as phenol, cresols, naphthalene and quinoline, but non-toxic tars are now available, and may be used instead of imported non-toxic bitumen. The free lime in freshly-laid cement is dangerous, but matured cement contains no poisonous substances.—*W. P. R.*

Dr. Rudolfs Heads Study of Stream Pollution. Anon. Munic. San. **9**: 129 (Feb. '38). W.P.A. chemical and bacteriological studies of N. J. water courses polluted by sludge deposits, are being made. The objects are, (1) determination of effects of wastes on oxygen and self-purification factors in streams, and (2) establishment of the best possible means of waste treatment. Latter to include recovery of worth-while by-products from industrial waste, making subsequent waste non-poisonous and unobjectionable when discharged into waterways. Studies are being made to treat this waste without hardship to industry.—*R. E. Noble.*

HYDROLOGY AND FLOODS

Weather and Water Supply. E. G. Bilham. Off. Cir. Br. W. W. Assoc. **20**: 29 (Jan. '38). Scientific study of weather statistics is concerned with av. conditions and degree of variability. To provide adequate water supplies not only necessary to know av. rainfall but also rainfall in driest individual yrs., and mo's. Av. rainfall figures in England and Wales based on the 35 yrs. 1881–1915. This period used as standard for comparison. In yrs. from '10–'36, only 6 yielded less than av. while 30 yielded more. 2 very dry yrs. included in period were '21 with rainfall 69% of av. and '33 with 81%. Av. 1881–1915 was 34.77", 1896–1930 was 36.29", probably indicating drier yrs. coming in near future. Relationship of annual run-off to annual rainfall for Thames basin to Teddington over period of yrs. is given by equation $F = 0.57\,R - 6.05$, a similar equation given by other observers for Severn basis is $F = 0.67\,R - 6.66$. For percentages of rainfall deficiency of 10, 20, 30, 40, and 50% the percentage deficiency of run-off was respectively for Severn basin—13.5, 27, 41, 54, and 68%; for Thames—14.2, 30, 46, 62, and 77%. Graphs are given showing these relationships in detail. As result of studies made in '30 on results up to '27 it was reported the greatest or least amt. of rain recorded at any station in any given no. of mo's tended to be about the same everywhere, when the value was expressed as a percentage of the av. annual fall at the station. Some of av's. for British Isles for 1, 5, 10, and 12 consecutive months for (a) least values—(b) greatest values (expressed in extremes of rainfall as percentages of the annual av. fall) are respectively; 0.3%–27%, 17%–83%, 49%–133%, 63%–154%. Comparison is made for driest months of '32–'35 at stations where drought was most intense. Special feature of '32–'35 drought was the unprecedented shortage resulting from the driest periods of about 23 to 35 mo's. in certain areas, on whole however, this drought was

fairly in accord with value to be expected from above mentioned study and Glasspoole's formula. In period aggregate rainfall was 81% whereas engineers for many yrs. have adopted 80% of normal as rainfall of 3 driest consecutive yrs. in estimating reliable yield of catchment area. Discussion of paper brings out impossibility of accurate detn. of losses of water, limitations of calendar divisions of time on data and fact that Oct. is the month of the beginning of winter rains.—*Martin E. Flentje.*

Southern California Coastal Plain Ravaged by Flood. N. A. BOWERS. Eng. News-Rec. **120**: 349 (Mar. 10, '38). Floods swept the whole of the Southern Calif. coastal plain area Mar. 2-5 as result of intense rainstorm that covered full width of state and was especially severe in steep mountain area bordering Los Angeles-Riverside plain on north. Despite excellent functioning of flood-control works so far completed, flood flow of all streams of region appears to have exceeded highest levels known. Estimated 200 fatalities and property loss estimated above $50,000,000. Streams are short and steep and floods subside quickly. Rain fell simultaneously on some 2500 sq. mi.: in coastal plain and foothills, rainfall was 5-13″ for entire storm: in mountain area, maxima were about 11″ in 8 hrs. and 15″ in 24 hrs. Flood-control dams decreased peak flows by one-third to one-half. No damage to Colorado R. Aqueduct was reported nor anything serious along Owens Valley Aqueduct. Considerable exposure of distribution mains occurred in San Fernando Valley. Conditions point strongly to need for detention reservoirs on coastal plain in addition to those in mountain valleys.—*R. E. Thompson.*

Mississippi Control Works Tested by Flood. J. L. SCHLEY. Eng. News-Rec. **120**: 533 (Apr. 14, '38). The flood of '37 reached stages, from Point Pleasant, W. Va., to Cairo, Ill., greater than ever before recorded. This greatest controlled flood in history was passed through Mississippi from Cairo to the Gulf without serious accident. Control works, functioning of which during flood is discussed in detail, performed their assigned parts, some better than anticipated, some perhaps not quite so well, but all well enough to have accomplished what was required of them. They saved the valley from what would otherwise have been the disaster of '37. As result of experience and information gained during flood, some improvements appear desirable and max. predicted flood has been modified for planning purposes to 2,600,000 sec.-ft. of runoff above Cairo and to over 3,000,000 sec.-ft. below mouth of Arkansas R. These runoffs are less than summation of max. recorded flows of all tributaries but are greater than any summation of flows that have ever synchronized thus far. In formulation of plans it can be assumed roughly that Mississippi R. carries 1,000,000 sec.-ft. below its banks, 2,000,000 sec.-ft. below its levee tops, and that the other 1,000,000 sec.-ft. should be restrained from or diverted from leveed channel.—*R. E. Thompson.*

Flood Control. W. H. CASSELMAN. Can. Engr. **74**: 11:12 (Mar. 15, '38). A general discussion, relating particularly to Ontario, of the effects which have followed indiscriminate clearing of forest lands. Control of floods by artificial means (reservoirs) may be advisable because of exigency, but re-

forestation of lands at headwaters of streams, all waste lands and portions of farms is only feasible means of restoring natural underground reservoirs that have been destroyed. Reforestation and forest preservation activities in Sweden and Finland are outlined and 7-point policy for Ontario is suggested.—*R. E. Thompson.*

Water Record of the Year. John C. Hoyt. Eng. News-Rec. **120**: 227 (Feb. 10, '38). Ample and well-distributed precipitation in most states resulted in generally normal streamflow. Precipitation was well above normal in most states east of the Mississippi R., there were deficiencies in all the semi-arid states and during some period of the yr. in most states there was abnormally large precipitation. No unusual shortages in water supplies reported. Adequate facilities now usually available to meet most deficiencies due to unusual weather conditions, as far as urban and industrial supplies are concerned. Three outstanding floods broke previous flood-flow records: Jan.-Feb. on Ohio R. and lower Mississippi R., May 28-June 4 on Pecos R. and in Dec. in northern Calif. Plans have been inaugurated by Weather Bureau leading to extension and enlargement of its flood warning service. Progress was made in methods and equipment for measuring flow in large rivers. Comparison of conditions in '37 with those of previous yrs. indicates that no predictions can be made as to when or where unusual weather and water conditions may prevail.—*R. E. Thompson.*

Geological Survey Studies Surface Waters. C. G. Paulsen. Civ. Eng. **8**: 247 (Apr. '38). Adequate information on the discharges and stages to be expected is essential to the design and construction of all hydraulic works. River measurement work of the U.S.G.S. has been carried on largely in co-operation with the various states. A number of studies of new equipment are being made as, e.g. the "pygmy" meter, a sounding reel accessory, and a boom with a gasoline motor for lowering and raising meters. To reduce the time required for determining the mean daily discharge from the gage-height graphs produced by a water-stage recorder, a special mechanical computer, called an "integrator" has been developed. Public works funds aggregating more than $1,300,000 have been allocated to the Survey, in addition to regular appropriations. Studies of flood magnitudes and frequencies for the principal rivers of the country have been made, and results published in recent water supply papers.—*H. E. Babbitt.*

HYDRAULICS

Analyzing Flow in Pipe Networks. Gordon M. Fair. Eng. News-Rec. **120**: 342 (Mar. 3, '38). Simplified application of Hardy Cross method for analysis of flow in networks of conduits or conductors (Bull. 286, Univ. of Ill. '36) is described in which original Williams and Hazen tables, Hazen and Williams' slide rule or diagram of Williams and Hazen formula is employed instead of the 2 tables, not ordinarily accessible to engineers, developed by J. J. Doland (Eng. News-Rec. Oct. 1, '36, p. 475). The incidental burden of calculation is reduced in this simplified application.—*R. E. Thompson.*

Economic Pipe Sizes for Water Distribution Systems. Discussion. Proc. A.S.C.E. **64**: 605. (Mar. '38). CLINTON L. BOGERT AND M. M. GREIG. The clever formulas derived exhibit the danger of carrying formulary regimentation into the realm of practical engineering. CHARLES M. MOWER. The often used "economic velocity" is not the correct standard for attaining true economy in distribution system design. When computations indicate an odd pipe size the next larger standard size pipe must be used. A. C. MICHAEL. For very small systems, where the character of the water demand is simple and where the piping arrangement is not complex, the method proposed probably could be used to advantage. Of the variables considered in the formulas, many are extremely indeterminate. The most difficult problem is the determination of average and maximum flow in a proposed pipe line. Seldom is the engineer confronted with the problem of designing a complete water-distribution system. The usual problem is to select pipe sizes that will meet average conditions of flow with normal pipe velocities, and maximum flow conditions with a respectable pressure at the consumers outlets.—*H. E. Babbitt.*

Reading Weir Elevations by Automatic Telegraphy. D. D. GROSS. Eng. News-Rec. **120**: 538 (Apr. 14, '38). Lake Cheeseman, the reservoir supplying Denver, Colo., is located in mountains 60 mi. from city. Reservoir is formed in narrow mountain canyons, traversed by South Fork of South Platte R. and Goose Creek. State laws require maintenance of measuring weirs at points where these streams enter reservoir, which are accessible only by 5-mi. trip by water. To overcome this inconvenience, Herman DeKoevena, caretaker of reservoir, has developed a signal device consisting of a drum, driven by a water turbine, on which are mounted lugs arranged according to a definite plan. A carriage, activated by a float in the stilling well and carrying phonograph and telephone transmitters moves back and forth above drum as depth of water over weir varies, the phonograph needle contacting a different system of lugs for each position of the float. By a switch in the office, the telephone is connected to the signal line and the readings, in dots and dashes, are transmitted to the nearest 0.01′. To accommodate both locations on one line, a clock-operated switch is inserted which connects the line to the 2 weirs alternately for 0.5-hr. periods. The dry cells used in operating the telephone line are only source of power required, except water turbine, which is driven by water from above the weir. The equipment can be employed as a recording device by substituting modified telegraph instruments for the telephone. A patent has been applied for.—*R. E. Thompson.*

A New Type of Fluid Rate Flow Meter. L. E. STOUT AND A. R. ROWE. Trans. Amer. Inst. Chem. Eng. **34**: 101 (Feb. '38). Study of the design of a fluid meter like the "Rotameter" to retain the advantages and minimize the disadvantages. Bob and cone types were constructed with calibration curves of approximately straight lines. The height of the bob is proportional to the rate of flow of the liquid. An increase in the taper of the cone causes a shift of the calibration curve in the direction of increased capacity. Changes in annular area of the bob tend to cause the calibration curves to spread fanwise from the point of initial flow. Bobs made of dense materials have cali-

bration curves which are shifted in the direction of greater capacity while bobs made of light materials produce meters having lower capacities. The sensitivity of the meter increases with a decrease in sp.gr. of the bob material and with a decrease in the annular area of the bob. A convenient way of inserting the meter in a pipe line is designed.—*O. M. Smith.*

The Use of Pipe Bends as Flow Meters. HERBERT ADDISON. Engineering (Br.) **145**: 227 (Mar. 4, '38). By use of pipe bends as flow meters flow can be measured with error of not much more than plus or minus 5%. The expression for the rate of flow around a bend in a circular channel is:

$$Q = C\sqrt{2gh}\,\frac{R^2 - (d/2)^2}{\sqrt{Rd/2}}\cdot\pi[R - \sqrt{R^2 - (d/2)^2}]$$

and around a bend in a rectangular channel is:

$$Q = C\sqrt{2gh}\,\frac{R^2 - (b/2)^2}{2\sqrt{Rb/2}}\cdot 2.3\,b\,[\log\,(R + b/2)] - \log\,(R - b/2)$$

in which Q = rate of flow around bend
C = coefficient for the bend; determined by calibration
R = mean radius of curvature of the bend
h = loss of head around the bend
d = dia. of a circular conduit
b = transverse width of a rectangular conduit

The most attractive feature of bends when used as water meters is naturally that they involve no additions or important alterations to an existing pipe system. They are limited to mean velocities greater than about 4′ per sec., and to a curvature ratio of R/b or R/d greater than 2.5, and to a value of h greater than about one ft.—*H. E. Babbitt.* (See also U. S. Dept. Agr., Tech. Bul. 577, abstract of which will appear in a later issue.)

The Measurement of Water Flow by the Salt-Dilution Method. O. KIRSCHNER. Wasserkraft u. Wasserwirt. **2**: 13 ('37); Wasser u. Abwasser **35**: 122. Dilns. above 1 to 30,000 give unreliable estimates. The method is useful for measuring torrential streams or uneven water flows. If c liters per second of strong salt soln. having a concn. of K_1 is added to a stream having an unknown flow C and a salt content of K_0 and after thorough mixing the concn. K_2 is detd. then C in liters per sec. equals $c(K_1 - K_2)/(K_2 - K_0)$.—*C. A.*

The Use and Trustworthiness of Small-Scale Hydraulic Models. PAUL W. THOMPSON. Civ. Eng. **8**: 255 (Apr. '38). Acceptance of the small-scale model has arisen not only from a faith in "the laws of similitude" but also from a lack of faith in methods of pure analysis. For almost any type of spillway the engineer can now find records of pertinent investigations to guide him in determining the general aspects of the design. Probably the day will come when model studies will consistently fail to indicate refinement of details—but that day is not yet at hand. Model data is obviously of increasing importance. Examples of model verifications are numerous, and two typical

ones are given. The verification phase of a small-scale model study forms the chief, and in many cases the only, item of evidence as to the model's trustworthiness. After examination of the many short-comings of the small-scale model, one's faith in model results is apt to decline, but, for all practical purposes, being the best tool available it is almost as good as being a perfect tool.—*H. E. Babbitt.*

Hydraulic Knowledge. J. C. STEVENS. Eng. News-Rec. **120**: 236 (Feb. 10, '38). Progress in hydraulics is reviewed. Model studies have become an indispensable tool linking theory and practice. A vast amount of hydraulic research is under way throughout the world, for the most part by models. The inherent limitations of models are being recognized, perhaps at some loss of prestige, but with an increase in knowledge of greater accuracy and value concerning basic principles. River control and reduction of scour below overflow dams have been advanced by model studies. The most important development in the field of hydrology is prediction of spring runoff in mountain streams by systematic snow surveys on the headwaters.—*R. E. Thompson.*

A Versatile Nomograph for Chemical Engineering Calculations. E. L. McMILLEN. Ind. Eng. Chem. **30**: 71 (Jan. '38). A universal nomographic chart is presented which makes possible direct multiplication and division by numbers raised to any power, facilitating solution of equations with fractional exponents more rapidly than with slide rule or logarithms, and with accuracy equal to that of slide rule. A combination nomograph and slide rule is also described.—*Selma Gottlieb.*

Flow of Boiling Water Through Orifices and Pipes. W. T. BOTTOMLEY. Trans. North East Coast Inst. Engrs. and Shipbuilders **53**: 65 ('36–'37). Theory is developed and test data are reported. Tests on orifices show that coeff. of discharge can be several times greater than unity because of surface-tension lowering of vaporization pressure. Practical applications of pipe flow data are suggested.—*R. E. Thompson.*

DAMS AND CONCRETE

First Ambursen-Type Dam in the Maritime Provinces. W. E. LUMB. Eng. Cont. Rec. **51**: 3:7 (Jan. 19, '38). Ambursen-type dam being constructed for Minas Basin Pulp and Power Co. on St. Croix R. about 3 mi. above St. Croix, N. S. Dam, which will provide operating head of 80′, consists of concrete deck at 45° angle, held in place by 14 buttresses at right angles to deck. The deck, 36″ thick at base and 18″ at top, consists of series of concrete slabs lying on the ends of the buttresses but separated from them by asphalt joints. Buttresses, which vary in length, are spaced 20′ apart and are 36″ thick at base and 14″ at top, resting on wide reinforced concrete base which goes down to solid rock. Cut-off wall at toe of dam is 35′ deep. Between each pair of buttresses is a vertical curtain wall, 18″ thick at bottom and 8″ at top, to keep air at even temp. across center of dam. Structure will require 15,000 cu. yd. of concrete and 550 tons of steel reinforcement and will raise water upstream for distance of 17 mi.—*R. E. Thompson.*

Keystone Dam Spillway Model. D. A. Buzzell. Eng. News-Rec. **120**: 542 (Apr. 14, '38). To facilitate fabrication and erection of 50,000-sec.-ft. "morning glory" spillway under construction at Keystone Dam in Nebraska, a 1/32 scale model was constructed, largely of plywood, at cost of $100. The morning glory is a 318′ overflow weir turned into circle 101′ in diam. at crest and warped down into 28.5′ tube which turns through 90° angle at ground line into 800′ tube passing under dam. An extension through the elbow to form temporary diversion tunnel during construction will be plugged with concrete when dam is completed. Spillway will be 170′ high and, with outlet tube and stilling basin, will cost about $1,500,000. Flow will be regulated by 12 tractor gates operated by 1 rotary electric hoist.—*R. E. Thompson.*

River Control and Water Storage in 1937. Anon. The Engr. (Br.) **165**: 23 (Jan. 7, '38). Two large water supply reservoirs are under construction in England. Manchester is to derive its water supply from the Mardale Valley through construction of the Haweswater dam. This dam will have a length of 1,550′ and height of 120′. The water level will be raised 95′ and reservoir will have capacity of 18 t 19 billion gal. (Imp.). Ladybower reservoir is being formed in the Derwent Valley by construction of an earth embankment with concrete core wall 1,250′ in length and height of 143′. Storage capacity will be 5.5 billion gal. (Imp.). The most important water supply works abroad is undoubtedly the Shing Mun dam near Hong Kong. The structure, completed in '37, has a reservoir capacity of 3 billion gal. (Imp). It is of unusual construction being built in separate panels with a sand wedge between the thrust block and rock to distribute the water pressure evenly. The dam is 285′ high. A large and unusual type of bell-mouth weir outlet is provided. In South Africa a big scheme is under way for the improvement of the water supply of Durban. A dam across the Umgeni river will impound 5 billion gal. (Imp.). It is of gravity section, 1,380′ long with a spillway 115′ above river level. For the conservation of water in connection with the Vaal and Hartz river schemes in South Africa the Vaalbank dam is under construction. It is situated 62 mi. south of Johannesburg. The reservoir will store 800,000 acre-ft. The works include a concrete dam and an earth embankment to cost 4 million pounds. Mention is also made of various important works for water supply and river control in the United States.—*H. E. Babbitt.*

Grand Coulee High Dam. Anon. Eng. News-Rec., **119**: 1021 (Dec. 23, '37). Design features, construction plans, chronology of the proposals made for the project and financial details of scheme are discussed. Project is combination power, river control and irrigation scheme. Dam, which will be world's most massive concrete structure, is key unit in system of 10 dams proposed for develment of Columbia R. Part of power produced will be used to pump to irrigation supply reservoir to be created simply by closing off the ends of the Grand Coulee, a mighty hanging valley whose floor is 600′ above present river level. Dam will create reservoir with capacity of almost 10,000,000 acre-ft., of which more than half is usable storage. This will equalize flow of river and result in reduction in flood peaks and improvement in navigation. Dam will raise water in storage reservoir about 350′ above ordinary river level and pumps will

lift it additional 280′ to balancing reservoir in Coulee. It is estimated that dam and reservoir will cost $128,450,000, of which dam will cost $118,123,000: estimated cost of ultimate power installation is $71,000,000 and of irrigation canals and balancing reservoir $195,000,000. Latter will probably not be started until dam is nearly completed. Entire project will take several decades to complete. Bids were opened on Dec. 10 for completion of dam, which is straight gravity structure, to ultimate height of 550′ and length of 4500′, which will require nearly 6,000,000 cu. yds. of concrete in addition to the 4,500,000 already in place. Mass concrete cooling system as used in base will be continued in the high dam. Contractor will be allowed 1460 days to complete the work. Pumping plant will contain twelve 1600-sec. ft. pumps driven by 65,000-hp. motors.—*R. E. Thompson.*

Shasta Dam Plans are Changed. ANON. Eng. News-Rec., **119**: (Nov. 18, '37). Shasta (Kennett) Dam is to be increased in size under revised plans announced by Bureau of Recl. bringing height to about 560′ and length to 3,100′. The dam, a concrete gravity structure located on upper Sacramento R. 13 mi. north of Redding, Calif., will contain 5,700,000 cu. yds. of concrete as compared with 4,360,000 cu. yds. for Boulder Dam and 11,250,000 for Grand Coulee Dam. Reservoir capacity will be 4,500,000 acre-ft. Dam is largest unit in the Central Valley project.—*R. E. Thompson.*

Butler, N. J. Builds New Dam for Municipal Water Works. ANON. Am. City. **52**: 12: 56 (Dec. '37). The Kikeout Reservoir dam being built for the Butler water works is designed to impound 850 mil. gal. of water over 170 acres. It will supply about 5 m.g.d. to Butler and neighboring towns through a concrete culvert. Of earth fill construction with a 425′ concrete core wall, the dam will carry a 10′ roadway across the top.—*Arthur P. Miller.*

A Dam and Bridge Laboratory. ANON. The Engr. (Br.) **165**: 135 (Feb. 4, '38). A laboratory for the testing of dams and bridges has recently been established at the Office Nationale des Recherches et Inventions at Bellevue, near Paris, France. The dams to be tested are built of reinforced concrete to exact scale, either 13.6:1 or 20:1. Smaller scale models built on tables will also be tested. The smaller models are built of reinforced plaster.—*H. E. Babbitt.*

Development in Soil Knowledge. GLENNON GILBOY. Eng. News-Rec. **120**: 241 (Feb. 10, '38). A summary of developments in soil mechanics during '37 and their application to construction problems, including settlement and subsidence, design of earth dams, compaction of sand dams and design of embankments on yielding foundations. Twelve references.—*R. E. Thompson.*

Underwater Exploration with Calyx Drills. HENDON R. JOHNSTON. Eng. News-Rec. **120**: 436 (Mar. 24, '38). Bed of Tennessee R. at site of proposed Watts Bar Dam was thoroughly explored by system of underwater boring with

calyx drills inside cofferdams that provided large holes as deep as desired for visual inspection of foundation strata in place. Rather extensive exploration by diamond drill method was carried out in '36, but core recovery in the uncemented shales was very poor. Procedure, devised by Tennessee Valley Authority engrs., is described in detail.—*R. E. Thompson.*

Shearing Stress in Gravity Dams. SERGE LELIAVSKY. J. Inst. C.E. (Br.) No. 4: p. 73 (Feb. '38). The safety of a dam design depends not only on the value of the maximum shearing stresses, but also, and essentially, on the manner in which they are distributed over the different points of the cross-section. It might, therefore, appear to be fortunate that the maximum shearing stresses in a gravity dam of the usual triangular type coincide in space with the zone of the highest compression intensities. In analysing a dam profile theories and conclusions with regard to shearing stresses serve also to determine the normal stresses acting on vertical planes. In general, a comprehensive picture of the stresses in the various parts of a dam profile could scarcely be obtained without an exhaustive analysis of the shearing stresses. The article then proceeds to a discussion of analytical and graphical methods for the analysis of these shearing stresses, and an illustrative example is carried out on the Assuit Barrage.—*H. E. Babbitt.*

Simple Methods and Equipment Test Seepage from Dams. S. S. GREEN. Eng. News-Rec. **120**: 466 (Mar. 31, '38). Special equipment in laboratory of Los Angeles Bureau of Water Works and Supply to facilitate tests of seepage waters from earth dams is described. Seepage is not considered detrimental unless percolating waters dissolve and bring away considerable quantities of solids. Ordinarily, the amount of solids is recorded in terms of tons per miner's inch of water flowing for a period of 1 yr. (1 miner's inch = 0.0244 sec.-ft.). For dams in Los Angeles water supply system, range of solid content is 5 to 40 tons per miner's inch per yr. and corresponding percentage of dissolved solids ranges from 0.025 to 0.200 tons per miner's inch per yr. An electric oven maintained at 160°F. was designed for evaporation of eight 100-gram samples in glass evaporating dishes. Attempts to weigh the hot dishes on an ordinary analytical balance resulted in errors of 5-60% due to convection currents, absorption of moisture, etc. To overcome these difficulties, an electric oven was built to fit under the balance and a balance pan hung therein, suspended from the balance arm by a wire passing through a hole drilled in the bottom of the balance case. On removing the dishes from the evaporating oven they are placed immediately on the balance pan in the weighing oven. Temp. of latter is raised to 315°F. and then allowed to cool to less than 300°F., during which period (7-8 min.) convection currents die out. The weighing is made at exactly 300°F. The oven is again raised to 315°, cooled to 300° and sample reweighed. The readings usually check within 0.001 gram, equivalent to a max. error of 2% in the usual range of dissolved solids.—*R. E. Thompson.*

A Simple Test for Water Permeability of Concrete. GEO. WILEY AND D. C. COULSON. J. Am. Concrete Inst. **9**: 65 ('37). Simple inexpensive app. is described which uses low pressures and gives results that check those pre-

viously obtained with high pressures. Increasing fineness of the cement greatly decreases permeability of concrete, especially under dry-curing conditions. At ordinary water/cement ratios dry-cured concrete is 2-3 times as permeable as moist-cured concrete. At all water/cement ratios, a dispersing agent produces concrete less permeable than concrete made with the corresponding plain cement.—*R. E. Thompson.*

Servicing Grout Pumps. A. W. SIMONDS AND V. L. MINEAR. Eng. News-Rec., **119**: 1018 (Dec. 23, '37). A discussion of grout pumps based on experiences in placing some 750,000 cu. ft. of cement grout in foundations and contraction joints of 6 western dams built or being built by U. S. Bur. of Recl. In general, pumps are preferable to injectors, although the pneumatic injector has advantages in special cases. Pumps are adaptable to variation in capacity required, speed decreasing as hole is filled until pump finally stalls when maximum allowable pressure is reached. The so-called slush pump most nearly meets all requirements, only substitution of special type piston being necessary for small quantities and low pressures. For larger amounts and moderate or high pressures rather extensive modification is required, but this is neither costly nor difficult, provided suitable pump is selected. Selection of pumps and their conditioning for grouting, maintenance and operation are discussed, with particular reference to valves, cylinder liners, pistons, packing and piston rods. Careful maintenance and operation will reduce delays and stops that often result in loss of drill holes or plugging of piping system.—*R. E. Thompson.*

Pumping Concrete on the Smaller Construction Jobs. C. F. BALL. Eng. Cont. Rec., **50**: 104: 14 (Dec. 22, '37). Equipment required for pumping concrete, i.e., the pump and pipeline, are described and conditions under which successful results may be obtained are discussed. Portable apparatus with capacity of 15-20 cu. yds. per hr. that may be used on comparatively small jobs is now available. Using the larger pumps, concrete may be forced through 1000′ of straight horizontal pipe or its equivalent or to heights of 100′ through pipeline of not more than 200′ of pipe. Nearly all commonly used mixtures are pumpable, provided they are of readily workable consistency. If sufficient good sand is used and slump is maintained at 2″ or more results will be consistently satisfactory. While concrete as dry as 1/2″ slump has been pumped successfully, most dependable slump is probably about 3″ and maximum distance and height is obtained with slump of 6 or 7″. Pumping may be stopped for periods of 15-30 min. or more and resumed without difficulty.—*R. E. Thompson.*

Foundation Caused Dam Failure. ANON. Eng. News-Rec. **120**: 281 (Feb. 24, '38). Squeezing out of pockets of plastic jelly-like material in the foundation caused failure of Wyandotte County Lake Dam, according to board of engrs. appointed to determine cause of collapse in report submitted Feb. 14. Dam failed by slumping of downstream bank for half length of structure. Underlying rock at dam site consists of horizontal layers of limestone and shale which are hard in their natural non-weathered state. No evidence of

faulting was found and there appears to be no reason to assign failure to rock foundation. Material overlying rock was found to contain high percentage of clayey soil: soil containing 40-50% clay was found at many locations and soil with 80% clay was found 250′ downstream. "The failure of the dam," report states, "resulted from a plastic movement of these foundation soils deficient in shearing strength in the region about 100′ downstream from the center line. The plastic movement was caused by overloading of the foundation by a combination of height of dam and steepness of slope." Visual analysis of borings without laboratory aid had led to belief that dam was founded on hard blue clay. Board reported that dam can safely be reconstructed if base width is increased to 1,000′ and area underlying downstream portion is cleared away to bedrock, involving excavation of most of downstream half of dam. It is recommended that area 700′ long extending 140′ downstream from center line be excavated to max. depth of 45′ to bedrock and then filled in with sand dredged from Mississippi R. Base should be broadended, center line moved upstream 159′ and present 90′ height raised about 6′. In addition, sheet pile cut-off wall and all material in puddle trench should be removed from dam "so that line of saturation would follow a normal gradient through the impervious rolled fill and the foundation seepage would not be forced to pass above the sheet piling." As originally built, dam was 1,550′ long, 550′ wide at base and about 50′ at the 80′ level to which it had been built. It had a puddled clay core and was constructed of clay placed in 8′ layers and compacted with sheepsfoot rollers.—*R. E. Thompson.*

The Subsidence of a Rockfill Dam and the Remedial Measures Employed at Eildon Reservoir, Australia. Rupert Grenville Knight. J. Inst. C.E. (Br.) No. 5: p. 111 (Mar. '38). Eildon Reservoir is formed by a rockfill dam completed in '27. It partly failed in '29 and during the succeeding 7 yrs. remedial measures costing £380,000 have been carried out. Reservoir constitutes portion of Golburn irrigation scheme. Dam made up of 2,525′ of rock-fill and 734′ of concrete spillway. Constructed of rock-fill the main bank supports a reinforced corewall 6′ thick at bedrock and 2′ thick at crest level, with construction joints 50′ apart. Max. height of dam is 153.7′. To increase impermeability of the reinforced concrete corewall clay was deposited on its upstream side, ranging in thickness from 27′ to 37′ with upstream batter of 6:1. In Apr. '29 when level of reservoir was 46′-6″ below its level of 5 mos. previously, the rockfill subsided over a length of 700′, and in May, after further lowering of the water level the subsidence had affected a length of 1,200′ of the dam. Greatest subsidence took place against the corewall and the exposed face was heavily scored due to pressure of the sliding stone. Max. deflection of corewall due to this pressure was 4′-8″. Board of Inquiry found that subsidence was due to the pressure of the clay causing the rockfill placed on its upstream side as a support for the mass, to slide into the reservoir. Remedial measures recommended consisted of placing 700,000 cu. yd. of additional rockfill. Behavior of corewall both as to impermeability and deflection was the subject of constant observation. Cracks occurred in all directions throughout it. All vertical cracks were repaired for their full height with mortar mixed with asbestos fibre 1 part, cement 8 parts, and sand 16 parts.

joints then coated with a bituminous paint before filling the vertical reconstruction shaft with clay-concrete. The clay-concrete consisted of 9% sand, 36% clay, and 55% quarry fines, mixed in a pug mill. Certain other cracks were calked with yarn against which cement mortar was tamped. Methods adopted in sealing cracks have proved satisfactory. To provide adequate drainage of downstream face 3′ dia. corewall drain was installed for a length of 1,700′ along the corewall, and thence at right angles to an outlet below the dam. Discharge from this drain makes possible measurement of leakage through the dam. After completion drainage from approximately 280,000 sq. ft. of corewall surface ranged from 24 to 48 g.p.m. (Imp.). Reconstruction of spillway and main outlet works was included in the remedial measures, all of which had been completed by Aug. '36.—*H. E. Babbitt.* (See also following abstract.)

Subsidence of a Rockfill Dam. Discussion of Remedial Measures Employed at Eildon Reservoir, Australia. ANON. Surveyor (Br.) **93**: 229 (Feb. 4, '38) Lateral pressure of the clay which had been placed on the water face of the core wall was cause of subsidence of the rockfill. (See preceding abstract for further data.) Subsidence in the Gorge Dam, China, a similar rockfill structure was studied by embedding in the fill steel plates attached to vertical steel rods extending through the fill, and taking levels periodically on the top of the rods. In a rockfill dam with a high central core wall it is essential that the material on either side of the core wall shall be rigid.—*H. E. Babbitt.*

WATER SUPPLY DEVELOPMENT

State Water Storage Upheld by Court. ANON. Eng. News-Rec. **120**: 521 (Apr. 14, '38). New Hampshire Supreme Court on Apr. 9 upheld constitutionality of New Hampshire Water Resources Board Act of '35 as amended in '37. The Act established a state corporation consisting of a 5-man state water resources board empowered to construct projects for conservation of water, but each project must be approved by governor and council of state after public hearings. Board may issue revenue bonds not constituting a debt of the state and in addition, the governor and council may pledge credit of state to amount not greater than $900,000. Cost of projects will be liquidated by payments from benefited water users, with whom contracts will be made for periods not greater than 50 yrs. Operation of projects will be directed by a water regulating committee. Act also authorizes governor and council to make agreements or compacts with any New England state for conservation, flood control and pollution control. First project planned is a $2,300,000 dam and reservoir (96,000 acre-ft. storage capacity) at headwaters of Connecticut R. near town of Pittsburg.—*R. E. Thompson.*

Unappropriated Waters Claimed for United States. ANON. Eng. News-Rec. **120**: 488 (Apr. 7, '38). Claiming that the U. S. owns all unappropriated water in North Platte R. free of control by states through which it flows, Attorney General Cummings on Apr. 1 requested permission of U. S. Supreme Court to intervene in suit brought by Nebraska against Wyoming and Col-

orado for apportionment of waters of that stream. Briefly, claim is that cessions of territory to U. S. by France, Spain, Mexico and Texas vested in federal government use of all waters except those privately owned at time of transfer. These rights have never been relinquished and therefore still remain in federal government. Fact that private appropriators have consistently sought and been granted water rights under laws of various states does not affect federal ownership of water still unappropriated, although such grants have materially diminished amount of such water remaining. In making these grants, states have been disposing of federal property with acquiescence of Congress, and resulting private rights have derived, not from state making grant, but from the U. S. Federal compliance with state laws in carrying out reclamation projects has been matter of comity and not of necessity.—*R. E. Thompson.*

Citizens Committee Favors Houston Water Plan. ANON. Eng. News-Rec. **120:** 517 (Apr. 7, '38). Committee of citizens appointed to study program for additional water supply for Houston, Tex., has recommended adoption of plan. Members of city council also favor program. Two alternatives were proposed by engineers to obtain water from San Jacinto R. Complete development of river at cost of $10,600,000 would provide capacity of 100 m.g.d., permitting abandonment of present well system and providing for city's water needs, it is estimated, until '80. Alternative plan, which was recommended by committee, would cost only $7,121,000 and provide 50 m.g.d. This scheme could be self-liquidating and placed in operation by end of next yr. It would involve construction of dam at Sheldon, 16 mi. from city, pumping plant at dam, canal to city, purification works, etc. Present well system, which has capacity of 25 m.g.d., would be gradually eliminated as wells dry up and river supply extended until fully developed.—*R. E. Thompson.*

Six Year Plan Made for Water Control. ANON. Eng. News-Rec. **120:** 388 (Mar. 17, '38). In report of National Resources Committee transmitted to Congress previous week, a 6-yr. program of investigation and construction for use and conservation of the water resources of the country was recommended which included lists of federal projects, total cost being $891,091,000 and weighted av. annual expenditure $200,624,000. These projects are intended to be carried out primarily with federal funds with some local contributions. Included also was a summary of recommended construction, primarily non-federal, which would involve 2,678 water supply projects costing $566,765,000 and 3,484 pollution abatement and sewerage projects costing $667,011,000. Progress in regard to compilation of basic hydrologic data, development of an integrated national water policy and stream pollution legislation during '37 were also reviewed.—*R. E. Thompson.*